ABSTRACT

MA, SHEN. Studies on Identifying Cucurbit Bacterial Fruit Blotch Resistant Resources with USDA Watermelon Germplasm. (Under the direction of committee chair Todd C. Wehner, PhD).

Cucurbit bacterial fruit blotch caused by *Acidovorax avenue* subsp. *citrulli* is a significant threat to watermelon [*Citrullus lanatus* (Thunb.) Matsum. and Nakai] production worldwide. Improved understanding the disease epidemiology of bacterial fruit blotch helped researchers come up with disease management strategies, including seed treatments to externally remove inoculum from seed coat, seed health testing assays and bactericide application. In the United States, watermelon production has moved to seedless cultivars, and critical requirements for seed germination make the production largely rely on transplant production in greenhouses to ensure a high germination rate. Unfortunately, the warm and humid greenhouse environment provides ideal conditions for the spread of bacterial fruit blotch. Despite the marginal success of current disease management strategies, they all have limitations. Resistant cultivars offer a solution to the problem, if genetic resistance can be identified. The objectives of this study were to 1) improve the resistance screening methodology in both field and greenhouse, 2) identify highly resistant germplasm to bacterial fruit blotch using the available Plant Introductions (PI) accessions in the USDA germplasm collection, 3) investigate the interaction between watermelon plants and bacterial fruit blotch via leaf surface morphological traits. Field evaluations based on foliar disease symptoms at the flowering stage were conducted at Clinton, NC in 2011 to 2013. The field experiment was a randomized complete block with 1,699 cultigens, 3 years, and 2 replications of single-plant plots. Disease rating was on a 0-9 scale when the disease was uniformly distributed across the field (0= no symptoms, 1-2 = trace, 3-4 = slight, 5-6 =

moderate, 7-8 = severe, and 9 = dead). Also, watermelon leaf surface structure was studied using the scanning electron microscope. Statistical analysis on weekly ratings showed that significant differences exist in disease severity among accessions (P=0.05). Resistant accessions were identified based on low mean, low standard deviation over replications, and high number of observations (few missing plots). The scanning electron microscope results revealed the impact of trichome and stomata on disease symptoms caused by bacterial fruit blotch.

Studies on Identifying Cucurbit Bacterial Fruit Blotch Resistance Resources with USDA Watermelon Germplasm

by
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BIOGRAPHY

I was born in Ziyuan Guilin, Guangxi, a small and quiet town in southwest China. My family ran a small business, so I had opportunities to interact with people, rich and poor, educated to illiterate, young and old, during my life there. I inherited the ability of making-peace with everyone from my mother. My father taught me to be an optimistic and ambitious person. Along with many good memories, I spent a happy childhood with my older brother under the care and love of my parents. In my early years, I spent 2 to 3 months each year in my parents' forest management work.

Rice was the major crop, and every fall, the harvest took a large amount of time and effort that impressed me greatly. In 2003, I decided to pursue a bachelor degree in Horticulture Science at Beijing Forestry University, where I studied botany, ecology, plant breeding, genetics, plant identification, and crop production. Of these courses, crop germplasm in China was a favorite. In my senior year, I worked with a graduate student on karyotypes of Chinese chrysanthemums for evolutionary relationships among varieties for chrysanthemum classification. The research experience made me interested in pursuing the subject further. In 2007, I began my Master of Science degree program at Mississippi State University and became interested in plant disease. My dream from childhood was to become a doctor, my interest in plant germplasm, and appreciation of food finally came together naturally: I had a project on identifying resistant resources to bacterial fruit blotch on the whole watermelon germplasm collection. Life always makes me believe that experience is a

valuable treasure and they are all connected. Finishing my PhD degree is not the end, but a fresh start for my dream to continue work in the world of plants.

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1 INTRODUCTION

Bacterial fruit blotch is a significant threat to watermelon production worldwide. The disease can cause 100% yield loss under ideal environmental conditions. Since seed is the primary inoculum for bacterial fruit blotch on cucurbit crops, the production of bacteria-free seed is a useful control method. Currently, the most effective strategy for managing bacterial fruit blotch has been excluding the pathogen from fruit to make sure the seeds and seedlings produced for the next generation are clean. The efficacy of external seed treatments varies because the pathogen can live under the seed coat. An effective control method would be to develop cultivars resistant to bacterial fruit blotch. As part of that effort, we initiated a three-year project to screen the watermelon germplasm collection for resistance, improve the testing methods, and select sublines of the most resistant cultigens. In the process, we hope to improve our understanding of the pathogen, and its interaction with the watermelon host.

2 DESCRIPTIONS OF THE CROP AND DISEASE

2.1 Watermelon Production

Watermelon [*Citrullus lanatus* (Thunb.) Matsum. and Nakai] is a species in the Cucurbitaceae. It is one of the most economically important cucurbit crops, mainly because of its popularity as a summer fruit in fresh market worldwide. From 2002 to 2012, with a 15% decrease in area harvested from 607 km^2 to 516 km^2, total production has remained consistent around 2 million Mg. The watermelon industry has increased in value from $497 million to \$520 million from 2003 to 2012 in the United States (USDA, 2004, 2013). In North Carolina in 2012, 34 km^2 of watermelons were produced with a value of \$35 million (USDA, 2004, 2013). The leading states in watermelon production in the US in 2012 were: Florida, Georgia, California, Texas, Indiana, and Arizona, all with long production seasons. Most watermelons grown in the US are seedless, so transplants are used extensively to improve germination and establishment rate (Maynard and Elmstrom, 1992). Hot and humid greenhouses and fields required for production also create a favorable environment for bacterial fruit blotch.

2.2 Cucurbit Bacterial Fruit Blotch

Bacterial fruit blotch is a seed-borne disease, caused by *Acidovorax avenae* subsp. *citrulli*, a gram negative bacterium, which is a member of the β-proteobacteria. (Schaad et al., 1978; Williams et al., 1992). Disease incidence ranges from 5 to 50%. When outbreaks occur early in the growing season, it might cause complete crop loss under ideal conditions (Latin and Hopkins, 1995). Bacterial fruit blotch has caused significant economic loss to the watermelon industry since the 1990s (Hodge, 1999).

When the watermelon fruit is affected by bacterial fruit blotch, the symptoms start as small, 1 cm diameter, dark olive green stains or blotches on the upper surface of infected fruit, and develop into necrotic spots 7 to 10 days later, along with an increase in spot size. In the advanced stage of the disease, the rind ruptures and the lesions ooze a sticky amber substance. Although bacterial fruit blotch does not affect the fruit flesh, secondary organisms cause fruit rot. Previous reports showed that bacterial fruit blotch could affect all plant growth stages from seed and seedling to flowering and fruiting (Walcott, 2005). Leaf lesions occur as small, dark brown, angular, and generally inconspicuous spots. Viewed from the bottom of the leaf, the margins of the lesion appear water-soaked. Stems, petioles, and roots usually are not affected. Symptoms on seedlings usually develop along major leaf veins. Foliar symptoms in the field are not distinctive and may be inconspicuous. In addition, foliar symptoms look like anthracnose, a foliar fungus disease caused by *Colletotrichum lagenarium* (Hopkins et al., 1993).

2.3 Disease Cycle/Epidemic

Contaminated seeds are the major inoculum source for bacterial fruit blotch epidemics. In transplant production greenhouses, overhead irrigation, and the warm and humid environment are favorable for disease establishment. Bacteria from infested seeds infect the developing seedlings as the cotyledons emerge from the seed coat. Splash from overhead irrigation helps to spread the inoculum to other seedlings. Secondary spread in transplant houses is responsible for a significant percentage of infected seedlings. In seed production fields, infected fruit produce infested seeds that become new inoculum for the start of the next disease cycle (Latin and Hopkins, 1995; Walcott, 2005). In the U.S., seedless watermelons dominate the market. The germination of seedless watermelons has critical requirement on temperature and water, which makes watermelon production rely significantly on transplant facility (Marr and Gast, 1991; Latin and Hopkins, 1993), which leads to an increased importance of the disease. Besides contaminated seeds and infested seedlings, the bacterium may invade watermelon fields from volunteer plants from previous seasons, other cultivated cucurbits, wild cucurbits, and cucurbit weeds (Isakeit et al., 1998; Latin and Hopkins, 1995).

2.3.1 Disease prevalence

Bacterial fruit blotch on watermelon was first observed in 1965 at the United States Department of Agriculture (USDA) plant introduction station, Griffin, GA (Webb and Goth, 1965). Scientists argued that bacterial fruit blotch could be introduced through contaminated commercial stock watermelon seeds when they were produced offshore (Rane and Latin, 1992; Hodge, 1999; Walcott, 2008). Later, the disease was discovered in commercial production fields in 1989 in Florida, South Carolina, and Indiana, causing losses up to 80% of the marketable fruit (Hopkins, 1989; Somidi et al., 1991). By 1999, bacterial fruit blotch had been reported in 15 states including Alabama, Arkansas, California, Delaware, Florida, Georgia, Indiana, Iowa, Maryland, Mississippi, Missouri, Oklahoma, North Carolina, South Carolina, and Texas.

2.3.2 Disease characteristics

When bacterial fruit blotch was first observed, pathologists identified foliar symptoms but not fruit symptoms. Therefore, the bacteria isolates used to be identified as *Pseudomonas syringae* pv. *lachrymans*. (Mullin and Schenck, 1963; Webb and Goth, 1965; Crall and Schenck, 1969). In 1978, the same genus: *Pseudomonas* was assigned to bacterial fruit blotch in Australia. The connection between the seedling disease and the fruit blotch symptoms was not made until an outbreak occurred in the Mariana Islands in 1987, with fruit symptoms rarely observed (Wall et al., 1990). After that, disease cycle and transmission was studied (Schaad et al., 1978; Wall, 1989; Wall and Santos, 1988; Wall et al., 1990), and the pathogen was identified as *A. avenae* subsp. *citrulli* based on, DNA-hybridization, biochemical and morphological characteristics (Somodi et al., 1991; Willems et al., 1992). Based on their studies, *A. avenae* subsp. *citrulli* is rod-shaped (0.5 x 1.7 µm) and an obligate aerobic. It does not fluoresce on King's Medium B (KMB), it is arginine dihydrolase negative, oxidase positive, gram-negative, and it has no pitting on semi-selective medium crystal violet pectate (CVP). The fastest bacterial development occurs between 39 to 42˚C, and produces white colonies on nutrient glucose agar (NGA). Colonies are lipolytic, starch hydrolysis is negative, and gelatin hydrolysis is slight. Usually, a hypersensitive response is observed on non-host crop tomato and tobacco in 24h (Somodi et al., 1991; Willems et al., 1992).

3 THREAT TO THE WATERMELON INDUSTRY

Since 1989, the bacterial fruit blotch disease outbreak has caused major economic loss in watermelon production in the U.S. In 1997, one grower declared a loss of 2.4 km^2 and more than $1.6 million (Hodge, 1999). In the Cukurova region of Turkey in 2009 to 2011, bacterial fruit blotch caused losses of watermelon and melon, with 5 km^2 (5000 da in paper) of watermelon fields quarantined against cucurbits for 4 years (Horuz et al., 2012). The popularity of triploid cultivars has resulted in increased transplanting, leading to increased disease incidence due to high temperature and humidity in transplant facility, which leads to increased bacteria dispersal from overhead irrigation. For seed companies, the disease has resulted in increased lawsuits from growers. Threat of litigation caused watermelon seed companies to suspend seed sales in 1994, when the bacterial fruit blotch epidemic was in 10 states. Companies who resumed sales later in 1994 required growers to sign liability waiver forms for the possible presence of bacterial fruit blotch (Latin and Hopkins, 1995). Without resistant cultivars, waiver forms and agreements are commonly used for growers, transplant producers, brokers, and packers/shippers who buy watermelon and melon seeds from seed companies (Rupp Seeds, 2012).

4 CURRENT CHALLENGES IN DISEASE MANAGEMENT

Since bacterial fruit blotch is seed-borne, contaminated seeds are the primary source of inoculum in both field and greenhouse (Hopkins and Thompson, 2002). Therefore, a range of external inoculum removal treatments have been suggested and tested to decontaminate cucurbit seeds. Those include treatment with NaClO, dipping in HCl, use of biological control with antagonistic microorganisms, or seed fermentation at harvest. Hopkins et al. (1996) evaluated the effects of seed fermentation for 24, 48, and 72 h alone, 1% HCl alone, 1% $CaOCl_2$ alone, and the combination of fermentation and HCl, $CaOCl_2$ followed with an air dry. They found 24 h seed fermentation in watermelon juice followed by a rinse and air dry eliminated bacterial fruit blotch seedling transmission, without adversely affecting seed germination. Seed fermentation therefore became one of the routine seed treatments for removing bacterial fruit blotch for the watermelon industry. This method, however, cannot be employed for triploid watermelon hybrid seeds due to deleterious effects on germination.

Chemical seed treatment with streptomycin sulphate, NaOCl, HCl, and/or $CaOCl_2$ reduced bacterial fruit blotch transmission on watermelon seedlings, with varying success depending on the study (Sowell and Schaad, 1979; Rane and Latin, 1992; Hopkins et al., 1996). In Hopkins's study, 1% HCl for 15 min eliminated bacterial fruit blotch incidence, while Rane and Latin found 1.5% HCl for 5 min reduced but did not eradicate bacterial fruit blotch on seedlings. Hopkins suggested a combination of fermentation and 1% HCl or $CaOCl_2$. This treatment reduced seed quality and might not be effective on other cucurbit crops. Peroxyacetic acid was tested to address these concerns. Peroxyacetic acid at 1600 μg/ml or higher for more than 30 min of seed exposure was most effective in eliminating bacterial fruit blotch on watermelon and other cucurbit crops with only minor adverse effects on seed germination (Hopkins et al, 2003). Dry heat treatment, chlorine gas exposure for 9 h, and acidic electrolyzed water (Hopkins et al., 1996; Hopkins et al., 2003; Shirakawa, 2003; Kubota et al., 2012; Stephen et al., 2008; Feng et al., 2009) were reported to be effective as well. Despite those results, none of the seed treatments were guaranteed to eliminate bacterial fruit blotch from seeds in day-to-day production, probably due to inoculum under the seed coat (Rane and Latin, 1992; Burdman and Walcott, 2012). In order to solve this problem; Johnson (Johnson et al., 2011) developed a nonpathogenic *A. citrulli* strain as a biocontrol seed treatment so that the pathogenicity of inoculum underneath of seed coat could be eliminated. The biocontrol method has not been tested commercially. Even if the seed treatments can remove the seed inoculum completely, contaminated volunteer watermelons, other cultivated cucurbits, wild cucurbits, and even cucurbit weeds are able to introduce bacteria to the crop when planted in the field (Isakeit et al., 1998; Latin and Hopkins, 1995; Hopkins and Thompson, 2002).

With a zero tolerance to bacterial fruit blotch in seedling transplant facilities, seed health testing has been developed and is considered to be critical for disease management. A PCR-based assay has been developed for the testing of seeds for *A. citrulli* (Bahar et al., 2008; YoungWhan and JumSoon, 2008; Walcott and Gitaitis, 2000). However, as cucurbit seeds contain PCR inhibitors, a range of techniques has been developed to improve the sensitivity and accuracy (Walcott et al., 2006; Walcott and Gitaitis, 2000; Zhao et al., 2009). Despite all of these improvements, the PCR-based technique has not become a routine testing assay in commercial production. Another popular method is the seedling grow-out bioassay, which relies on large seed samples (n= 10,000-50,000 seed/lot) under favorable disease development conditions. The downside to this method is that sampling is time consuming and labor intensive.

Bacterial fruit blotch can be controlled in the field using multiple applications of a copper-containing bactericide including cupric hydroxide, copper hydroxyl sulfate, or copper oxychloride (Hopkins, 1991; Hopkins and Thompson, 2002). The available commercial brands are Kocide and ManKocide from DuPont. The copper bactericides work by coating the leaf surface with minute particles of copper that then react with acid and moisture on the leaf surface to release copper ions that kill bacteria. It is not systemic, so good coverage and excellent retention on the leaf surface are required (Ritchie, 2004). Despite of their marginal success in reducing *A. avenae* subsp. *citrulli* in the greenhouse and fields, and because copper bactericides are the only chemical control available, their widespread use raises concerns and risks of generating copper-resistant isolates of the bacterium (Hopkins, 1995; Walcott et al., 2004; Wechter et al., 2011).

Resistant cultivars would be an effective strategy for managing bacterial fruit blotch if they could be developed. In addition to cost effectiveness, resistance-based strategies are compatible with other integrated disease management approaches. To date, there are no cucurbit cultivars with resistance to bacterial fruit blotch.

5 CURRENT STATUS ON BACTERIAL FRUIT BLOTCH RESEARCH

5.1 Host Genotype Diversity and Geographic Distribution

Before the 1990s, bacterial fruit blotch was reported primarily on watermelon in the USA and Guam. In the 1990s, outbreaks were reported throughout the central, eastern and southeastern USA in states including Florida, Texas, Georgia, South Carolina, North Carolina, Illinois, Iowa, Missouri, Delaware, Oregon, and Oklahoma (Black et al., 1994; Hamm et al., 1997; Jacobs et al., 1992; Latin and Rane, 1990; Somodi et al., 1991).

The disease was limited to regions with a hot and humid growing season and it was not observed in cooler or drier regions such as California. More recently, however, the disease has been reported in many cucurbit production regions around the world on a wide range of hosts. Bacterial fruit blotch has been reported on watermelon, muskmelon, honeydew, citron, cantaloupe, bur gherkin, acorn squash, cucumber, pumpkin, yellow squash, zucchini squash, and wax gourd in general production as well as in grow-out studies (Isakeit et al., 1997; Isakeit et al., 1998; Langston et al., 1999, Walcott et al., 2000; Kubota et al., 2012; Hopkins and Thompson, 2002). All cucurbit crops should be considered sources for the introduction of *A. avenae* subsp. *citrulli* into the transplant house or field (Hopkins et al., 2003). The geographical center of origin for *A. avenae* subsp. *citrulli* is not known (Walcott, 2008).

Bacterial fruit blotch transmission was reported in Australia on watermelon, rockmelon, prickly paddy melon, honeydew, gramma and cucumber (Martin and Horlock, 2002; Martin and O'Brien, 1999; O'Brien and Martin, 1999). Transmission was reported in Mexico, Honduras, Brazil, Nicaragua, and Costa Rica on watermelon and melon (Assis et al., 1999; Macagnan et al., 2003; Mora-Umana and Araya, 2002; Munoz and Monterroso, 2002). Transmission was reported in Taiwan on melon and watermelon (Macagnan et al., 2003). Transmission was reported in Turkey on watermelon (Demir, 1996; Mirik et al., 2006). Transmission was reported in Israel on watermelon and melon (Burdman et al., 2005). Transmission was reported in Japan on watermelon (Shirakawa et al., 2000). Transmission was reported in Xinjiang, Neimenggu, Fujian, and Jilin in China on Hami melon and watermelon (Cai et al., 2005; Fan and Ma, 2004; Jin et al., 2004; Ren et al., 2006; Zhao et al., 2001).

5.2 Host Resistance to Bacterial Fruit Blotch

5.2.1 Progress overview

Most economic losses due to bacterial fruit blotch have been reported in watermelon and melon (Wall and Santos, 1988; Wall et al., 1990; Somodi et al., 1991; Latin and Hopkins, 1995; Schaad et al., 2003; Isakeit et al., 1997; O'Brien and Martin, 1999; Burdman et al., 2005). Resistance has been studied on these two crops (Sowell and Schaad, 1979; Somodi et al., 1991; Hopkins et al., 1993; Hopkins and Thompson, 2002; Carvalho et al., 2012; Bahar et al., 2009; Wechter et al., 2011). Attempts were made to increase watermelon resistance to bacterial fruit blotch (Hopkins and Levi, 2008). PI 295843, PI 299378 and 'Congo' were more resistance than 'Charleston Gray' or 'Jubilee' when tested in seedling inoculation assays (Sowell and Schaad, 1979). 'Garrisonian' was reported to be immune (Goth and Webb, 1981). However, PI 295843, PI 299378, 'Congo' and 'Garrisonian' were later found to be susceptible, possibly due to different bacterial strains or environmental factors (Hopkins et al., 1993).

A screening study was conducted to look for bacterial fruit blotch resistance in 2002 using 1,344 *Citrullus spp.* and *Praecitrullus fistulosus* accessions. They reported several resistant accessions: PI 482279 (Zimbabwe), PI 494817 (Zambia), PI 500303 (Zambia), PI 500331 (Zambia) and PI 482246 (Zimbabwe) based on a greenhouse seedling test and field test confirmation, of which, PI 482279 and PI 494817 were the most resistant ones. The self pollinated selections of these 5 accessions were more resistant than the original accessions. The selected resistant accessions, however, showed segregation in resistance (Hopkins and Thompson, 2002). Segregation in resistance to bacterial fruit blotch was also reported in screening tests involving the melon germplasm collections (Wechter et al., 2011). Although

PI 482279 had bacterial fruit blotch resistance, it was pumpkin shaped fruit with light-green rind, tough peach-colored flesh, and brown medium size seeds. PI 494817 had round fruit with dark green rind, tough cream-colored flesh, and large black seeds. A project was initiated to incorporate resistance from PI 482279 and PI 494817 into a watermelon cultivar ‘Crimson Sweet’ with good horticultural characteristics as well as to investigate the inheritance of resistance. By the third backcross, horticultural traits including fruit shape, flesh color and flesh soluble solids were approaching those of 'Crimson Sweet'. The disease ratings on the F_1, F_2, BC_3 and BC_3S_2 populations developed from PI 482279, PI 494817 and 'Crimson Sweet' indicated that resistance was controlled by more than one gene and the mode of inheritance was complex. The complexity made it difficult to maintain the resistance while attempting to improve horticultural traits by crossing with 'Crimson Sweet' (Hopkins and Levi, 2008).

A Brazilian group tested 74 watermelon accessions for bacterial fruit blotch resistance, and found that BGCIA 979, BGCIA 34 and ‘Sugar Baby’ were resistant at most plant developmental stages after inoculation with bacterial fruit blotch group I strain. They suggested these three accessions could be used in watermelon breeding programs in Brazil (Carvalho et al., 2012).

5.2.2 Challenge in screening for resistance to bacterial fruit blotch

The greenhouse seedling test and field test are similar, and both emphasize high temperature and high relative humidity to promote symptom development (Hopkins et al., 1993; Hopkins and Thompson, 2002; Bahar et al., 2009; Wechter et al., 2011; Carvalho et al., 2012).

Because bacterial fruit blotch could potential infest any stage of plant, Carvalho et al., (2012) evaluated watermelon resistance at different stages including seed, seedling, flowering, and fruiting and found significant differences. Similar results were reported for melon bacterial fruit blotch screening (Bahar et al., 2009).

Although there has been much effort to identify highly resistant accessions of watermelon (Sowell and Schaad, 1979; Rane and Latin, 1992; Hopkins et al., 1993; Hopkins and Thompson, 2002; Hopkins and Levi, 2008), no resistant cultivars have been developed. Poor screening methods, complex interactions between host and pathogen, and environmental variability have contributed to the slow progress.

Efforts have been made to improve the screening method to facilitate identification of plants with resistance to bacterial fruit blotch. In early tests of watermelon cultivars, light-colored fruit rind such as 'Charleston Gray' was associated with susceptibility, while dark-colored rind such as 'Sugar Baby' was associated with resistance (Hopkins et al., 1993). In later screening of the watermelon germplasm collection, resistant accessions PI 482279 and PI 494817 had light-green rind (Hopkins and Thompson, 2002). In another study, 'Sugar Baby' with dark rind color was identified as resistant to bacterial fruit blotch group I strain type in Brazil (Carvalho et al., 2012). However, the focus was on foliar symptoms mostly at seedling stage in both greenhouse and field (Sowell and Schaad, 1979; Somodi and Jones, Hopkins et al., 1993; Hopkins and Thompson, 2002; Carvalho et al., 2012; Bahar et al., 2009; Wechter et al., 2011). There are problems with the methods for testing resistance. First, the foliar symptoms can be difficult to identify, resembling other diseases such as anthracnose

(*Colletotrichum lagenarium*) (Hopkins et al., 1993). Second, disease-rating methods differ among studies. Third, the screening method focused on testing at the seedling stage in the greenhouse but there was a significant effect of growth stage on bacterial fruit blotch (Bahar et al., 2009; Carvalho et al., 2012).

Inoculation of pistillate flowers with *A. citrulli* with a high cfu/ml caused a significant increase in infection of watermelon seeds (Walcott et al., 2003; Lessl et al., 2007). This is one way through which the pathogen penetrates the stigma to infect the integument, which develops into the seed coat. With the ability of the stigma to discriminate incompatible pollen, the stigma also has the ability to defend against pathogens using the cascade gene expressions and secretion of organic compounds (Hodgkin et al., 1988; Feys et al., 1994; Pusey 2004). However, the importance of flower inoculation in screening for bacterial fruit blotch resistance has been overlooked in the past while evaluating watermelon resistance to bacterial fruit blotch.

The bacterial fruit blotch pathogen has different strains with different virulence levels (Somodi et al., 1991). The subspecies type strain and strains from the 1989 outbreak in Florida were found to differ based on fatty acid profiles and the ability to cause a hypersensitive response on tobacco. Two distinct groups of *A. avenae* subsp. *citrulli* were suggested based on utilization of L-leucine and 2-amino ethanol in Australia (O'Brien and Martin, 1999). Walcott et al. (2004) suggested at least 2 distinct groups (Group I and Group II) of *A. avenae* subsp. *citrulli* among 64 collections from USA, China, Australia, Brazil, Canada, Nanjing, Israel, and Thailand. The conclusion was based on the DNA fingerprinting by pulse-field gel electrophoresis and repetitive extragenic palindromic polymerase chain reaction. The pathogenicity test showed that group II strains were more aggressive on watermelon than on other hosts while group I strains were more aggressive on other cucurbits hosts. Group II probably also has variability for pathogenicity, which could result in different reactions by the host in resistance screening. For example, when inoculated with strain CB-9 isolated from diseased cotyledons in Georgia, Sowell and Schaad reported that "*P. pseudoalcaligenes* subsp. *citrulli* [it was assigned to *A. avenae* subsp. *citrulli* in 1990 (Wall et al., 1990)] had little effect on watermelon foliage in the field, but was damaging when used to inoculate seeds (Sowell and Schaad, 1979). However, bacterial fruit blotch caused significant economic loss on watermelon in Florida in 1989. Strains WBF89-1 and WBF89-2 were isolated from this outbreak and were used for resistance screening on watermelon cultivars and 1,344 watermelon accessions (Hopkins et al., 1993; Hopkins and Thompson, 2002). Although strains WFB89-1 and WFB89-2 were isolated from diseased plots they may not have been the most virulent strains. Also, environmental conditions play an important role in bacterial fruit blotch epidemics and are not always conducive to high disease incidence.

Regardless, environmental conditions for screening resistance to bacterial fruit blotch are of great importance. It is easier to optimize the environment with high temperature and humidity if a greenhouse with intermittent mist system is used (Rane and Latin, 1992), or seedlings wrapped in water-soaked paper towels in an incubator (Hopkins and Thompson, 2002), or seedlings tested in a growth chamber (Johnson et al., 2011). For large field tests, it is more difficult to maintain an environment conducive to disease, and where significant differences can be detected.

Thus, it may be useful to run a screening of all available germplasm accessions using a highly conducive environment, a mix of virulent isolates, and multiple growth stages to identify genes controlling resistance at each stage.

With all the background information on BFB, we decided to 1) develop screening methods for severe and uniform disease development, and 2) screen the USDA watermelon germplasm collection for high resistance to bacterial fruit blotch and to identify the most resistant accessions for use in inheritance studies.

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CHAPTER 2 Screening Watermelon Germplasm for Resistance to Bacterial Fruit Blotch

ABSTRACT

Cucurbit bacterial fruit blotch caused by *Acidovorax avenue* subsp. *citrulli* is a significant threat to watermelon [*Citrullus lanatus* (Thunb.) Matsum. and Nakai] production worldwide. In the United States, seedless cultivars are primarily used in watermelon production, and now relies largely on transplant production in greenhouses to ensure a high germination rate. Unfortunately, the warm and humid greenhouse environment provides ideal conditions for the spread of bacterial fruit blotch. Treatments designed to remove bacteria from the surface of the seed coat were investigated previously, but none eliminated the bacteria despite significant effects reported in research studies. Resistant cultivars offer a solution to the problem, if genetic resistance can be identified. The objectives of this study were to 1) identify new highly resistant germplasm to bacterial fruit blotch using the available Plant Introductions (PI) accessions in the USDA germplasm collection, and 2) improve the field screening methodology. Field evaluations based on foliar disease symptoms at the flowering stage were conducted at Clinton, NC in 2011 to 2013. The field experiment was a randomized complete block with 1699 cultigens, 3 years, and 2 replications of single-plant plots. Disease rating was on a 0-9 scale when the disease was uniformly distributed across the field (0= no symptoms, 1-2 = trace, 3-4 = slight, 5-6 = moderate, 7-8 = severe, and 9 = dead). Multiple times of rating were taken each year. Statistical analysis on weekly ratings showed that significant differences exist in disease severity among accessions ($P=0.05$).

Resistant accessions were identified based on their best ratings, less than 4.5, low standard deviation over replications, and multiple replication (≥4). The 23 selected resistant cultigens mainly originate from Zimbabwe, Zambia, South African and Nigeria and they were either *C. lanatus* or *C. lanatus* var. *citroides*.

1 INTRODUCTION

Watermelon ([*Citrullus lanatus* (Thunb.) Matsum. and Nakai]) belongs to the Cucurbitaceae family and is one of most economically important cucurbit crops, the watermelon industry has been threatened by bacterial fruit blotch (*Acidovorax avenae* subsp. *citrulli*) commercially since 1989 in the United States (Hopkins, 1989). Bacterial fruit blotch is a seed-borne disease. Disease incidence is 5 to 50%, with complete crop loss under ideal conditions, especially when the outbreaks occur early in the growing season (Latin and Hopkins, 1995). Bacterial fruit blotch has caused significant economic loss to the watermelon industry since the 1990s (Hodge, 1999). Most economic losses of bacterial fruit blotch have been reported in watermelon and melon (Wall and Santos, 1988; Wall et al., 1990; Somodi et al., 1991; Latin and Hopkins, 1995; Schaad et al., 2003; Isakeit et al., 1997; O'Brien and Martin, 1999; Burdman et al., 2005). Resistance resources have mainly been identified on these two crops (Sowell and Schaad, 1979; Somodi et al., 1991; Hopkins et al., 1993; Hopkins and Thompson, 2002; Carvalho et al., 2012; Bahar et al., 2009; Wechter et al., 2011). Attempts were made to increase watermelon resistance to bacterial fruit blotch (Hopkins and Levi, 2008).

Since bacterial fruit blotch is seed-borne, contaminated seeds are the primary source of inoculum in both field and greenhouse (Hopkins and Thompson, 2002). Therefore, a range of external inoculum removal treatments have been suggested and tested to decontaminate cucurbit seeds. Those include treatment with NaClO, dipping in HCl, use of biological control with antagonistic microorganisms, or seed fermentation at harvest (Sowell and Schaad, 1979; Rane and Latin, 1992; Hopkins et al., 1996). Seed fermentation became one of the routine seed treatments for removing bacterial fruit blotch for watermelon industry. Seed fermentation, however, cannot be employed for triploid watermelon seeds due to deleterious effects on germination. The chemical seed treatment of streptomycin sulphate, NaOCl, HCl, $CaOCl_2$, and peroxyacetic acid reduced bacterial fruit blotch transmission on watermelon seedlings, with varying success depending on the study (Sowell and Schaad, 1979; Rane and Latin, 1992; Hopkins et al., 1996; Hopkins et al., 2003). Dry heat treatment, chlorine gas exposure for 9 h, and acidic electrolyzed water (Hopkins, 1996; Hopkins et al., 2003; Shirakawa, 2003; Kubota et al., 2012; Stephen et al., 2008; Feng et al., 2009) were reported to be effective as well. Despite those results, none of the seed treatments were guaranteed to eliminate bacterial fruit blotch from seeds in day-to-day production, probably due to inoculum under the seed coat (Rane and Latin, 1992; Burdman and Walcott, 2012). Biocontrol was developed by creating a type III secretion system mutant of *A. citrulli*. This mutant was able to colonize germinating watermelon seeds but lost pathogenicity to watermelon due to missing type II secretion system. The colonize ability of mutant strain then reduced the concentration of wild type of bacterial fruit blotch underneath of seed coat, resulted in a reduced disease incidences (Johnson et al., 2011). No data have been published on its effect in large commercial production. Even if the seed treatments can remove the seed inoculum completely, contaminated volunteer watermelons, other cultivated cucurbits, wild cucurbits, and even cucurbit weeds are able to introduce bacteria to the crop when planted in the field (Isakeit et al., 1998; Latin and Hopkins, 1995; Hopkins and Thompson, 2002).

Once in the field, bacterial fruit blotch can only be controlled in the field using multiple applications of a copper-containing bactericide including cupric hydroxide, copper hydroxyl sulfate, or copper oxychloride (Hopkins, 1991; Hopkins and Thompson, 2002). It is not systemic, so good coverage and excellent retention on the leaf surface is required (Ritchie, 2004). Despite of the marginally successful in reducing *A. avenae* subsp. *citrulli* in the greenhouse and fields, and because they are the only chemical control available, their widespread use raises concerns and risks of generating copper-resistant isolates of the bacterium (Hopkins, 1995; Walcott et al., 2004; Wechter et al., 2011).

Resistant cultivars would be an effective strategy for managing bacterial fruit blotch if they could be developed. In addition to cost effectiveness, resistance-based strategies are compatible with other integrated disease management approaches. To date, there are no cucurbit cultivars with resistance to bacterial fruit blotch (Sowell and Schaad, 1979; Rane and Latin, 1992; Hopkins et al., 1993; Hopkins and Thompson, 2002; Hopkins and Levi, 2008).

In the United States, screening based on 1,344 *Citrullus spp.* and *Praecitrullus fistulosus* accessions revealed PI 482279 (Zimbabwe) and PI 494817 (Zambia) as the best resistant resource to bacterial fruit blotch. Meantime, PI 500303 (Zambia), PI 500331 (Zambia) and PI 482246 (Zimbabwe) were recommended as valuable sources for resistance. All these accessions are *C. lanatus* var. *citroides* (Hopkins and Thompson, 2002). Because of undesirable horticultural traits in PI 482279 and PI 494817, a project was initiated to incorporate resistance from PI 482279 and PI 494817 into 'Crimson Sweet' with desirable horticultural traits and to investigate the inheritance of resistance. By the third backcross, horticultural traits including fruit shape, flesh color and flesh soluble solids were approaching those of 'Crimson Sweet'. Also, the study found that resistance to bacterial fruit blotch from PI 482279, PI 494817 was controlled by more than one gene. The complexity of the resistance inheritance and/or the difficulty in introgression of resistance from wild watermelon into cultivars made it difficult to maintain the resistance while attempting to improve horticultural traits by crossing with 'Crimson Sweet' (Hopkins and Levi, 2008). Thus, new resistant sources are needed.

The bacterial fruit blotch pathogen has different straits with different virulence levels (Somodi et al., 1991). The fatty acid profiles, utilization of L-leucine and 2-amino ethanol and DNA fingerprinting by pulse-field gel electrophoresis and repetitive extragenic palindromic polymerase chain reaction suggested there are different groups of strains (O'Brien and Martin, 1999; Walcott et al. 2004). Now, it is widely acceptable to name the two groups of strain as group I and II developed by Walcott (2004). The pathogenicity test showed that group II strains were more aggressive on watermelon than on other hosts while group I strains were more aggressive on other cucurbits hosts.

The objectives of this study were to 1) develop screening methods for severe and uniform disease development, and 2) screen the USDA watermelon germplasm collection for new resistance resource to bacterial fruit blotch and to identify the most resistant accessions for use in inheritance studies.

2 MATERIALS AND METHODS

2.1 Plant Materials and Cultural Practices

A collection of 1,699 watermelon plant introduction (PI) accessions from the USDA Regional Plant Introduction Station (RPIS) at Griffin, GA was screened for flowering stage plant resistance to Group II bacterial fruit blotch, caused by *Acidovorax avenae* subsp. *citrulli* . The accessions originated from 73 countries (Table 2.1). Field tests were run at the Horticultural Crops Research Station in Clinton, NC in 2011 to 2013. The station is located at 35.02°N latitude and 78.28° E longitude. All available USDA watermelon accessions were included, along with the exotic *Citrullus* plant introduction (PI) accessions and a diverse set of cultivars (Table 2.2). Besides the primary gene pool of *Citrullus lanatus*, the exotic germplasm provided another four species and varieties: *C. colocynthis, C. lanatus* var. *citroides, C. rehmii,* and *Praecitrullus fistulosus*, which were categorized as secondary or tertiary gene pools based on their cross ability with *C. lanatus* and studies of genetic diversity (Levi et al., 2011). Each year there were 1,689 cultigens tested.

Seeds of the PI accessions were directly seeded in single-plant hills, using 2 to 10 seeds/hill, based on seed availability and germination rate. In the field, raised beds were made up with drip irrigation tubes and covered with black polyethylene mulch. Rows were on 3.1-m centers with hills 1.2 m apart. We used recommended horticultural practices (Sanders, 2004). Soil type was an Orangeburg loamy sand and prime for farmland. Plants were thinned to one plant/hill three weeks after seeding (4 to 6 true leaf stage). Overhead irrigation was applied to the field twice/week to encourage disease development and spread.

2.2 Experiment Design

Field screening. The experiment was a randomized complete block with 1,689 cultigens, 3 plantings in 2011, 2012, and 2013 with each planting having 2 replications. A third replication in 2013 was unusable due to problems with seedling establishment. Planting of each replication was on 18 and 21 July in 2011, 18 and 25 June in 2012, and 28 May and 15 July in 2013.

Retest. Field resistance from the germplasm screening study was validated in the retest study. In 2012, the 2011 germplasm screening data were used to choose the 17 most resistant and 2 most susceptible cultigens for the retest using a rating scale from 0 (healthy) to 9 (dead) (Table 2.3). In 2013, the 2012 germplasm screening data were used to choose the 20 most resistant and 1 most susceptible cultigens for the retest. Field plots were 3.7 m long with 6 plants evenly spaced. Cultural practices were the same as for the germplasm screening. The experiment was a randomized complete block design with 4 replications in each year. The retest study was planted 18 June 2012, and 13 May 2013.

2.3 Inoculation Method

In 2011 and 2012, inoculum was spread through the field test from natural inoculum carried on the planted seeds. Diseased leaf samples were collected periodically from the field to confirm the presence of bacterial fruit blotch. Disease diagnosis and bacterial isolation were conducted by the Plant Disease and Insect Clinic at North Carolina State University. The disease was spread in the field by overhead irrigation, and vine training done regularly by the field crew.

In 2013, plants were inoculated using a foliar spray when plants reached the 4- to 6-true leaf stage. The inoculum consisted of a bacterial suspension of group II strains AAC 00-1 and AAC 94-21. Bacterial fruit blotch of AAC 00-1 and AAC 94-21 were obtained from Dr. R. Walcott and were collected from Georgia in 1990 and 1994, respectively (Walcott, et al., 2004). The strain isolates were grown on nutrient agar (VWR, Radnor, PA) for 48 h and washed from the agar surface with deionized water. In the field, the suspension was diluted to 10^6 cfu/ml. Surfactant Islet L-77® (Momentive™, Albany, NY) was added at 0.03% ratio before inoculation to lower the leaf surface tension. A dosage of 10 ml suspension was applied as a mist to each plant with a hand-sprayer.

2.4 Field Bacterial Isolate Identification with Biolog

Diseased leaf samples were collected from Clinton, NC in the summer of 2012.
Pure colonies of *A. avenae* subsp. *citrulli* isolates were then grown on Biolog Universal Agar media (Biolog Inc. Hayward, CA), for 24 h at 30°C in an IsoTemp™ incubator (Fisher

Scientific™, Waltham, MA). A cell suspension was made of 1×10^8 cfu/ml using inoculating fluid (Biolog Inc. Hayward, CA), before measuring on a spectrophotometer. Then, 150 µl of cell suspension was transferred into a Biolog GN2 microtitre plate followed by incubation at 30°C for 20 to 24 h. During incubation, a purple color forms in each well where the substrate was used by the bacteria (the result of tetrazolium redox dye). The microtitre plate was loaded into a Biolog Microstation and the color pattern and intensity measured spectrophotometrically and matched to a library of known bacterial utilization patterns using Microlog software V.4.2 (Biolog Inc. Hayward, CA). The group II was determined based on the use of sole carbon substrates by *A. avenae* subsp. *citrulli* (Walcott et al., 2004).

A preliminary study to test pathogenicity of bacterial strains of AAC 00-1 and AAC 94-21 was run on seedlings in the greenhouse before use in the large field tests (data not listed).

2.5 Data Collection and Analysis

Disease ratings were taken weekly based on foliar disease symptom using a 0-9 scale (Table 2.3). In 2011, disease ratings were started 7 weeks after planting. In 2012, disease ratings were started 6 weeks after planting. In 2011 and 2012, data were standardized by using the ratings 8, 9 and 10 weeks after planting. In 2013, data were taken 3, 4 and 5 weeks after planting, or 1, 2, and 3 weeks after inoculation. Hereafter, ratings (as described above) over the 3 years are referred to as ratings 1, 2 and 3. The first replication in 2013 was removed from analysis due to inferior plant stands, but was used for the selection of cultigens having low variability (Table 2.11). In 2013, another replication was planted to replace replication 1 due to lack of plant in many cases. Therefore, a total of 3 years with 2 replications and 3 ratings were used for the data analysis. Foliar disease ratings were subjected to analysis of variance using the general linear model procedure of SAS 9.2 (SAS Institute, Cary, NC). Means were tested using Fisher's protected least significant difference with P = 0.05.

Fruit photographs were taken on 15 August 2013 to record horticultural traits including flesh color, flesh firmness, rind color and pattern, and seed color. Plant size was evaluated with a scale of 1-5 on 22 cultigens in the 2013 retest on June 24, 2013 (1 = small, 2 = medium, 3 = intermediate, 4 = large, 5 =vigorous).

3 RESULTS

3.1 Germplasm Screening

In total, 1,699 watermelon cultigens including wild accessions, related species, and elite cultivars were screened for field resistance at flowering-stage to the bacterial fruit blotch Group II strains at the Horticultural Crops Research Station in Clinton, NC from 2011 to 2013. Not all cultigens were tested in 2 replications for 3 years. There were 48 cultigens missing from 6 replications; 47 missing from 4 replications; 1 missing from 3 replications; 45 missing from 2 replications, and 8 missing from 1 replication (Table 2.4). Of the missing cultigens, a majority of them were from Turkey, followed by Yugoslavia and India. Results and data analysis were based on cultigens tested 2 or more replications. The complete dataset (see Appendix) has been submitted to GRIN (http://www.ars-grin.gov).

The ANOVA indicated significant differences (P=0.0001) in disease resistance among cultigens for all 3 ratings (Table 2.5). The best ratings for each replication were determined by ANOVA with data summarized by year. In all 3 years, rating 3 had the largest F ratio, so rating 3 was used as the best rating for differentiating cultigen resistance. Mean rating (over the 3 ratings) was similar to the best rating in cultigen F ratio (4.12 vs. 3.94, respectively; Tables 2.6 and 2.7).

Compared to ratings 1 and 2, rating 3 had the largest F ratio for cultigen in the ANOVA for each year, and for the mean over years (Table 2.5). Of the total variance, 76, 82 and 80% was explained by ratings 1, 2, and 3, respectively.

The most resistant and most susceptible cultigens were chosen based on mean of rating 3, with consideration for the uniformity over years and replications, and having few missing observations. Resistant cultigens for rating 3 was 5.5 or less, while a mean rating was 3.5 or less. The most resistant cultigens mainly originated from Zimbabwe (21), South Africa (17), Zambia (9) and Nigeria (7). The most susceptible cultigens for rating 3 was 7.0 or higher.

3.2 Germplasm retest

The most resistant cultigens from the germplasm screening were retested the following year to confirm their resistance. In the retest studies of 2012 and 2013 retests (Table 2.9 and Table 2.10), there were 8 resistant cultigens (PI 271770, PI 482246, PI

482277, PI 482319, PI 482324, PI 482331, PI 482342 and PI 596666) that appeared in both years.

The most resistant cultigens ranged from 2.0 to 5.8 for rating 3 in the 2012 retest and 2.0 to 5.0 for rating 3 in the 2011 germplasm screening (Table 2.9). PI 271770 and PI 532670 were the most resistant cultigen in the 2011 germplasm screening. Again PI 271770 was the most resistant cultigen in the 2012 retest. PI 482342 had the worst rating (5.8) of all the resistant cultigens. Data were not obtained from PI 482246 and PI 532670 due to poor germination. PI 525100 and PI 164665 were consistently susceptible in the 2011germplasm screening and the 2012 retest. The check cultivars 'Calhoun Gray', 'Mickylee', and 'Crimson Sweet' were not as susceptible as the most susceptible accessions but were more susceptible that the resistant accessions (except PI 482342) in the 2012 retest. All these tested cultigens showed consistency in ratings in 2012 and 2013 screening except PI 532670, PI 482342 (6 in 2012 screening) and PI 596692 (6 in 2013 screening).

The most resistant cultigens ranged from 1.0 to 2.5 for rating 3 in the 2013 retest and 1.3 to 6.0 for rating 3 in the 2012 germplasm screening (Table 2.10). PI 482246 was the most resistant cultigen in the 2012 germplasm screening, while PI 482322 and PI 596666 were the most resistant cultigens in the 2013 retest. The resistant cultigens from the 2012 germplasm screening were more resistant than the check cultivar 'Charleston Gray'. PI 635598 was consistently susceptible in both the 2012 germplasm screening and the 2013 retest with rating 3 values of 6.0 and 4.9, respectively.

3.3 Data Validation

The 23 most resistant cultigens were identified in 2011 to 2013 (Table 2.11). Of those, 5 were in the 2012 and 2013 retest studies (Table 2.8 and Table 2.9): PI 271770, PI 482246, PI 482277, PI 596666, and PI 596668. Another 5 cultigens were in a single retest study: PI 296342, PI 482309, PI 482322, PI 500354, and PI 596665. Several of the resistant cultigens had similar origins: PI 271770 and PI 271779 from South African, PI 482273 and PI 482277 from Zimbabwe, PI 500331 and PI 500332 from Zambia, and PI 596665, PI 596666, PI 596668, and PI 596696 from South Africa. Most of them were from South Africa, Zimbabwe and Zambia with the exception of PI 560006 (Nigeria) and PI 595201 (United States selection from PI 189317, origin Zaire). Even though not selected as the best resistant cultigens, PI 560000, PI 560010, PI 560014, and PI 560023 showed to have relatively high resistance to bacterial fruit blotch. Similarly, PI 595200 developed from PI 189317 (Zaire) showed relatively high resistance (Table 2.8).

Four cultigens that had uniform disease data were selected to represent the germplasm from Maldives, India, Yugoslavia, and Iran.

We found that some of the resistant cultigens showed variability over the years and some cultigens showed variability in ratings over the replication within one year. Similar variability was also found within inbred cultivar checks on ‘Charleston Gray’ and ‘Mickylee’ (Table 2.11).

3.4 Correlation

Pearson and Spearman correlations between all fruit blotch ratings were significant (P=0.0001) in the germplasm screening from 2011 to 2013 (Table 2.12). Average rating was highly correlated with all weekly ratings. The maximum rating was mostly from week 3, but sometimes occurred on the week 2 rating. Usually, rating 3 was the most severe of the 3 ratings for disease, and permitted the best ability to distinguish resistance among the watermelon cultigens, as indicated by Pearson and Spearman correlation coefficients between the ratings on weeks 1, 2 and 3.

Correlations between pairs of weekly ratings in 2011, 2012 and 2013 were low but significant (Table 2.13). In the 2011 and 2012 germplasm screening, when disease naturally occurred by the inoculum carried on seeds, we found that correlations between ratings were not very different from correlations between ratings in 2013, when we used artificial inoculation. Future research should be aimed at developing better testing methods for greater repeatability over rating weeks and testing years.

3.5 Horticultural Traits

Overall, resistant cultigens were more vigorous than the susceptible check. There was a significant effect in plant size among all the cultigens in 2013 retest (Table 2.10). PI 482331 was more vigorous than all other cultigens and PI 271770 was the least vigorous cultigen. All the resistant cultigens except PI 271770 were more vigorous than the susceptible check PI 635598. ‘Charleston Gray’ was also more vigorously large than PI 635598 even though not significantly but was less vigorous than most of the resistant cultigens.

Flesh color and rind pattern was different among the resistant cultigens (Figure 2.1). Two cultigens had red flesh (PI 271770 and PI 482300), 4 cultigens (PI 271779, PI 500354, PI 596668 and PI 596669) had yellow or orange flesh, and 6 had white flesh (PI 482277, PI 500328, PI 532670, PI 560008, PI 596665, and PI 595203). PI 271779, PI 500354, PI560008 and PI 596669 had solid dark green rind; PI 532670, PI 596668 and PI 595203 had light green rind. PI 560008 was an Egusi type with fleshy pericarp around the seeds.

4 DISCUSSION

4.1 Germplasm Screening

The germplasm screening for watermelon resistance to bacterial fruit blotch in the field from 2011 to 2013 was successful in differentiating highly resistant, moderately resistant and susceptible watermelon cultigens in the USDA watermelon germplasm collection. The 2012 and 2013 retests confirmed the resistance of the cultigens that were selected.

The AVOVA showed a significant effect for both cultigen and cultigen by year interaction. The field screening for resistance to bacterial fruit blotch based on foliar symptoms was effective in revealing differences in resistance among individual plants. Overall, the ratings in 2011 were higher than the ratings in 2012 and 2013. We were able to identify cultigens that had resistance over years and replications. Of the five species and botanical varieties in the watermelon germplasm collection, only *C. lanatus* and *C. lanatus* var. *citroides* had accessions showing resistance. Previous studies showed that certain PI accessions of *C. lanatus* var. *citroides* had resistance to important diseases of watermelon, including gummy stem blight (Gusmini et al., 2005), *Fusarium* wilt (Martyn and Netzer, 1991), and root-knot nematode (Thies and Levi, 2007). Most of the *Praecitrullus fistulosus* and *C. colocynthis* accessions in our study were susceptible to bacterial fruit blotch. Two of the accessions of *C. rehmii* had slight resistance to bacterial fruit blotch in 2013, and the other two had incomplete data.

4.2 Resistance Resources

South Africa, Zimbabwe, Zambia, and Nigeria were the sources of many of the resistant PI accessions. Whether or not the rates of resistance to bacteria fruit blotch are higher among PI accessions collected from these 4 countries is a testable hypothesis. *Citrullus lanatus* (Thunb.) Matsum. et Nakai var. *citroides* is indigenous to the arid and sandy regions of Southern Africa (Bates and Robinson, 1995). This species is considered the progenitor of cultivated watermelon (*C. lanatus* var. *lanatus*) and the Tsamma watermelon (*C. lanatus* var. *citroides*). Similarly, most of the resistant accessions identified by Hopkins and Thompson (2002) were from Zimbabwe or Zambia.

The most resistant accessions identified by Hopkins and Thompson (2002) were PI 482279 (Zimbabwe) and PI 494817 (Zambia). PI 500303 (Zambia), PI 500331 (Zambia), and PI 482246 (Zimbabwe) were also resistant. Our results showed that PI 482273, PI 482277, and PI 4822246 from Zimbabwe, and PI 500328, and PI 500331 from Zambia were resistant to bacterial fruit blotch. PI accessions were collected from all over the world and sequential PI numbers were assigned to those that were collected in adjacent places. According to latitude and longitude data from GRIN for accession original collection, we found that PI 482273 and PI 482277 were from the same location, and close to the place where PI 482279 was collected (GRIN, 2013). Thus, they may be related in their bacterial fruit blotch resistance.

Since Zimbabwe, Zambia and South African are in southern Africa, the accessions collected from Nigeria (in West Africa) might be of particular importance in terms of genetic background for resistance. Some interesting accessions are the egusi type from Nigeria: PI 56000, PI 560006, PI 560010, PI 560014, and PI 560023 which are *C. lanatus*. They are in the primary gene pool of watermelon and may be easier to use to develop resistant cultivars. The previous study of integrating resistance to bacterial fruit blotch from *C. lanatus* var. *citroides* PI 494817 and PI 482279 into 'Crimson Sweet' did not succeed (Hopkins and Levi, 2008). Introgression of favorable alleles from wild watermelon, such as *C. lanatus* var. *citroides* into cultivars is difficult because many favorable alleles are closely linked to undesirable fruit traits (Levi et al., 2011). However, since only one Egusi type watermelon PI 560019 was retested in 2012, additional testing is needed to confirm their resistance.

We did not find an association of dark rind color with resistance to bacterial fruit blotch as reported in other studies (Hopkins et al., 1993), although most of the resistant cultigens did have more vigorous vine growth as reported by Levi et al. (2011).

The susceptible checks in the 2011 and 2012 retest PI 164665, PI 525100, and PI 635598 were susceptible to bacterial fruit blotch and developed large leaf spots, but they were not killed during the tests. Similarly, the check cultivar 'Charleston Gray' was susceptible compared to most of the PI accessions but was not killed by bacterial fruit blotch. ‘Sugar Baby’ was one of the more resistant cultivars to bacterial fruit blotch (Hopkins and Thompson, 2002; Carvalho et al., 2012) but we found it to be susceptible. A large number of accessions were killed during our tests. However, they may have died due to something else other than bacterial fruit blotch, so were not selected as susceptible checks.

Most of the selected resistant accessions had uniform disease ratings with some variability over replications. It is possible that resistance in some accessions was segregating based on various disease ratings (Hopkins and Thompson, 2002). After all, seeds of most PI accessions were originally collected from different locations around the world, representing populations rather than inbred lines. Also, the plant introduction station uses open pollination of sibs to increase seeds of most accessions. Therefore, PI accessions might be heterogeneous, with genetic differences among plants. It is also possible that resistant accessions have occasional susceptible plants in them. Thus, researchers should self pollinate and select the most resistant plants within the resistant accessions to develop resistant inbred lines for further use.

4.3 Screening Methodology

Variation in disease ratings in our tests may be due to variation in environmental conditions. All the check cultivars including ‘Charleston Gray’ and ‘Mickylee’ are inbred lines, but their disease ratings varied over years and replications. Test uniformity has been improved using field inoculation and overhead irrigation, but we need to work on other variables, such as seed quality, and to help improve the screening results.

Foliar symptoms need to be identified accurately, but we found the leaf symptoms vary among accessions. Disease symptoms reported decades ago by Mullin and Schenck (1963) and Webb and Goth (1965) have become the standard for advising growers for disease identification in the field. Based on our observations, some plants had extended water-soaked lesions with a greasy look while others only developed chlorosis. Some plants developed leaf lesions in a cluster while others developed spots only sporadically.

The time required to develop disease symptoms fully varied among PI accessions, and the appearance of visible symptoms was controlled by the availability of free moisture on the leaves (Panagopoulo and Crosse, 1964). In this study, with natural inoculation carried on the seeds, it took 8 weeks for the first symptoms to appear, and 10 weeks for the majority of PI accessions to show symptoms as the result of rain, wind, vine training and overhead irrigation (Walcott, 2005). Artificial inoculation with virulent strains shortened the time to 3 weeks after inoculation for the most useful stage of disease ratings. The shortened time also reduced the chance for the accessions to be exposed to other diseases appearing in late summer, such as anthracnose, powdery mildew, and downy mildew. In this study, it was important to take multiple ratings in the field throughout the season for comparison over years.

Environment played an important role in our tests. Since the disease requires a warm and humid environment, we should conduct the screening from June to August in North

Carolina as we did. It is important to use overhead irrigation several days before inoculation, and then continue afterwards to get good disease ratings.

4.4 Future Studies

There were 104 PI accessions missing in at least 4 replications in this study. In order to make the screening for bacterial fruit blotch data more complete, these accessions need to be tested using a better seed source. Out of the 62 resistant PI accessions, we chose 23 for future studies because of their consistent response over three years and also because of their diverse seed sources. Most of them were only tested in single-plant hills, so their resistance needs to be confirmed in replicated plots.

In order to understand the resistance inheritance, pure lines of these resistant cultigens should be developed by self-pollination of the accessions for several generations. Also, crosses of resistant and susceptible cultigens should be made to study the inheritance of resistance. The horticultural traits in those selected resistant cultigens were not desirable so improvement by backcrossing to elite watermelon cultivars will be needed.

5 CONCLUSIONS

The field screening for bacterial fruit blotch resistance has resulted in the identification of 23 resistant accessions of watermelon in the USDA germplasm collection. Similar to other watermelon disease resistance studies, *C. lanatus* var. *citroides* contributed to large number of the 23 resistant accessions. Besides Zimbabwe and Zambia that were common origins for resistance to bacterial fruit blotch, South Africa and Nigeria were also origins. The accessions from Nigeria may be of importance for cultivar improvement because these sources are *C. lanatus*.

Additional tests of resistant accessions will be needed to confirm their resistance. Finally, artificial inoculation using a mix of virulent strains is recommended to shorten the time for disease development that may improve the uniformity of ratings over the replications.

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Table 2.1. Countries of seed origin and number of cultigens (Plant Introduction accessions from the USDA-ARS, cultivars and breeding lines) Watermelon germplasm collection evaluated for resistance to bacterial fruit blotch (*Acidovorax avenae* subsp. *citrulli*) from 2011-2013 in Clinton, NC, USA.

Seed source	No. of cultigens	Seed source	No. of cultigens
Afghanistan	26	Maldives	17
Algeria	3	Mali	12
Angola	1	Mauritania	1
Belize	6	Mexico	8
Bolivia	4	Moldova	1
Botswana	16	Morocco	1
Brazil	3	Namibia	2
Bulgaria	1	Nigeria	48
Cameroon	2	Pakistan	26
Canada	1	Paraguay	3
Chad	4	Philippines	7
Chile	1	Portugal	2
China	71	Russia	9
Cuba	1	Senegal	11
Cyprus	1	Sierra Leone	1
Egypt	22	Somalia	8
El Salvador	1	South Africa	61
Ethiopia	11	Soviet Union	17
France	4	Spain	76
Gabon	1	Sudan	7
Ghana	15	Syria	31
Greece	6	Taiwan	2
Guatemala	2	Thailand	1
Honduras	1	Tunisia	2
Hungary	12	Turkey	308
India	137	Turkmenistan	1
Indonesia	4	Ukraine	6
Iran	40	United States	129
Iraq	3	Unknown	2
Israel	8	Uruguay	1
Italy	3	Uzbekistan	6
Japan	15	Venezuela	6
Jordan	2	Yugoslavia	184
Kazakhstan	1	Zaire	10
Kenya	3	Zambia	69
South Korea	25	Zimbabwe	157
Lebanon	9	Total	1699

Table 2.2. Species/variety and number of cultigens from the USDA-ARS. Watermelon germplasm collection evaluated for resistance to bacterial fruit blotch (*Acidovorax avenae* subsp. *citrulli*) from 2011-2013 in Clinton, NC, USA.

Species/variety	Number of PI accessions
Citrullus lanatus	1,533
Plant Introduction accession	1,471
Cultivar	58
Breeding line	4
C. colocynthis	18
C. lanatus var. *citroides*	116
C. rehmii	4
Praecitrullus fistulosus	28
Total	1,699

Table 2.3. Subjective rating scale for field assessment of watermelon foliar resistance to bacterial fruit blotch (*Acidovorax avenae* subsp. *citrulli*) at flowering stage.

Subjective Rating	Percent of leaf area affected by chlorosis and/or necrosis	Size of leaf lesion caused by chlorosis and/or necrosis	Description of symptoms
0	0-9	None	Health, no symptoms
1	10-19	Small	Trace
2	20-29	Small	Trace
3	30-39	Medium	Slight
4	40-49	Medium	Slight
5	50-59	Large	Moderate
6	60-69	Large	Moderate
7	70-79	Extended	Severe
8	80-89	Extended	Severe
9	90-100	Extended	Plant dead

Table 2.4. The list of cultigens (Plant Introduction accessions from the USDA-ARS, cultivars and breeding lines) that were missing in the watermelon germplasm screening from year 2011 to 2013 with their country of origin and species/variety.

Cultigen	Missing replications	Seed source	Species/variety
PI 179662	1	India	*Citrullus lanatus*
PI 295843	1	South Africa	*Citrullus lanatus*
PI 314178	1	Soviet Union	*Citrullus lanatus*
PI 177331	1	Syria	*Citrullus lanatus*
PI 169239	1	Turkey	*Citrullus lanatus*
PI 176493	1	Turkey	*Citrullus lanatus*
PI 177327	1	Turkey	*Citrullus lanatus*
PI 177329	1	Turkey	*Citrullus lanatus*
PI 212288	2	Afghanistan	*Citrullus lanatus*
PI 542115	2	Botswana	*Citrullus lanatus*
PI 542122	2	Botswana	*Citrullus lanatus*
Grif 1733	2	China	*Citrullus lanatus*
PI 560901	2	China	*Citrullus lanatus*
PI 593388	2	China	*Citrullus lanatus*
PI 525085	2	Egypt	*Citrullus lanatus*
PI 525090	2	Egypt	*Citrullus lanatus*
PI 185635	2	Ghana	*Citrullus lanatus*
PI 271750	2	Ghana	*Citrullus lanatus*
PI 271751	2	Ghana	*Citrullus lanatus*
PI 212208	2	Greece	*Citrullus lanatus*
PI 270144	2	Greece	*Citrullus lanatus*
PI 195771	2	Guatemala	*Citrullus lanatus*
Grif 14199	2	India	*Citrullus lanatus*
PI 164687	2	India	*Citrullus lanatus*
PI 164708	2	India	*Citrullus lanatus*
PI 179884	2	India	*Citrullus lanatus*
PI 182934	2	India	*Citrullus lanatus*
PI 183022	2	India	*Citrullus lanatus*
PI 183124	2	India	*Citrullus lanatus*
PI 183125	2	India	*Citrullus lanatus*
PI 183398	2	India	*Citrullus lanatus*
PI 270143	2	India	*Citrullus lanatus*
PI 381720	2	India	*Citrullus lanatus*

Table 2.4 continued

PI 211849	2	Iran	*Citrullus lanatus*
PI 229605	2	Iran	*Citrullus lanatus*
PI 179242	2	Iraq	*Citrullus lanatus*
PI 270522	2	Israel	*Citrullus lanatus*
PI 270525	2	Israel	*Citrullus lanatus*
PI 227204	2	Japan	*Citrullus lanatus*
PI 279461	2	Japan	*Citrullus lanatus*
PI 319237	2	Japan	*Citrullus lanatus*
PI 508442	2	South Korea	*Citrullus lanatus*
PI 612470	2	South Korea	*Citrullus lanatus*
PI 181742	2	Lebanon	*Citrullus lanatus*
PI 490385	2	Mali	*Citrullus lanatus*
PI 549159	2	Mauritania	*Citrullus lanatus*
PI 184800	2	Nigeria	*Citrullus lanatus*
PI 559994	2	Nigeria	*Citrullus lanatus*
PI 560017	2	Nigeria	*Citrullus lanatus*
PI 560018	2	Nigeria	*Citrullus lanatus*
PI 250146	2	Pakistan	*Citrullus lanatus*
PI 269465	2	Pakistan	*Citrullus lanatus*
PI 274795	2	Pakistan	*Citrullus lanatus*
PI 171392	2	South Africa	*Citrullus lanatus*
PI 270565	2	South Africa	*Citrullus lanatus*
PI 295848	2	South Africa	*Citrullus lanatus*
PI 299563	2	South Africa	*Citrullus lanatus*
PI 596692	2	South Africa	*Citrullus lanatus*
PI 512344	2	Spain	*Citrullus lanatus*
PI 512385	2	Spain	*Citrullus lanatus*
PI 537470	2	Spain	*Citrullus lanatus*
PI 537472	2	Spain	*Citrullus lanatus*
PI 481871	2	Sudan	*Citrullus lanatus*
PI 534598	2	Syria	*Citrullus lanatus*
PI 164992	2	Turkey	*Citrullus lanatus*
PI 169232	2	Turkey	*Citrullus lanatus*
PI 169234	2	Turkey	*Citrullus lanatus*
PI 169240	2	Turkey	*Citrullus lanatus*
PI 169241	2	Turkey	*Citrullus lanatus*

Table 2.4 continued

PI 169242	2	Turkey	*Citrullus lanatus*
PI 169243	2	Turkey	*Citrullus lanatus*
PI 169244	2	Turkey	*Citrullus lanatus*
PI 169246	2	Turkey	*Citrullus lanatus*
PI 169248	2	Turkey	*Citrullus lanatus*
PI 169249	2	Turkey	*Citrullus lanatus*
PI 169250	2	Turkey	*Citrullus lanatus*
PI 169252	2	Turkey	*Citrullus lanatus*
PI 169253	2	Turkey	*Citrullus lanatus*
PI 169264	2	Turkey	*Citrullus lanatus*
PI 169271	2	Turkey	*Citrullus lanatus*
PI 169274	2	Turkey	*Citrullus lanatus*
PI 169275	2	Turkey	*Citrullus lanatus*
PI 169277	2	Turkey	*Citrullus lanatus*
PI 169279	2	Turkey	*Citrullus lanatus*
PI 169285	2	Turkey	*Citrullus lanatus*
PI 169286	2	Turkey	*Citrullus lanatus*
PI 169288	2	Turkey	*Citrullus lanatus*
PI 169299	2	Turkey	*Citrullus lanatus*
PI 172791	2	Turkey	*Citrullus lanatus*
PI 174101	2	Turkey	*Citrullus lanatus*
PI 174108	2	Turkey	*Citrullus lanatus*
PI 175661	2	Turkey	*Citrullus lanatus*
PI 176908	2	Turkey	*Citrullus lanatus*
PI 176916	2	Turkey	*Citrullus lanatus*
PI 176918	2	Turkey	*Citrullus lanatus*
PI 176919	2	Turkey	*Citrullus lanatus*
PI 176921	2	Turkey	*Citrullus lanatus*
PI 176922	2	Turkey	*Citrullus lanatus*
PI 177319	2	Turkey	*Citrullus lanatus*
PI 179237	2	Turkey	*Citrullus lanatus*
PI 183673	2	Turkey	*Citrullus lanatus*
PI 204689	2	Turkey	*Citrullus lanatus*
PI 277986	2	Turkey	*Citrullus lanatus*
PI 278012	2	Turkey	*Citrullus lanatus*
PI 278031	2	Turkey	*Citrullus lanatus*

Table 2.4 continued

PI 278040	2	Turkey	*Citrullus lanatus*
PI 278041	2	Turkey	*Citrullus lanatus*
PI 278053	2	Turkey	*Citrullus lanatus*
PI 278055	2	Turkey	*Citrullus lanatus*
PI 344301	2	Turkey	*Citrullus lanatus*
Black Diamond YB	2	United States	*Citrullus lanatus*
Golden	2	United States	*Citrullus lanatus*
Hopi Red Flesh	2	United States	*Citrullus lanatus*
Jubilee	2	United States	*Citrullus lanatus*
PI 600792	2	United States	*Citrullus lanatus*
PI 635592	2	United States	*Citrullus lanatus*
Stone Mountain	2	United States	*Citrullus lanatus*
Sugar Baby	2	United States	*Citrullus lanatus*
Super Sweet	2	United States	*Citrullus lanatus*
Sweet Princess	2	United States	*Citrullus lanatus*
Sweet Heart	2	United States	*Citrullus lanatus*
Tastigold	2	United States	*Citrullus lanatus*
PI 251796	2	Yugoslavia	*Citrullus lanatus*
PI 357665	2	Yugoslavia	*Citrullus lanatus*
PI 357669	2	Yugoslavia	*Citrullus lanatus*
PI 357670	2	Yugoslavia	*Citrullus lanatus*
PI 357671	2	Yugoslavia	*Citrullus lanatus*
PI 357681	2	Yugoslavia	*Citrullus lanatus*
PI 357724	2	Yugoslavia	*Citrullus lanatus*
PI 357725	2	Yugoslavia	*Citrullus lanatus*
PI 357726	2	Yugoslavia	*Citrullus lanatus*
PI 357737	2	Yugoslavia	*Citrullus lanatus*
PI 357751	2	Yugoslavia	*Citrullus lanatus*
PI 368509	2	Yugoslavia	*Citrullus lanatus*
PI 368510	2	Yugoslavia	*Citrullus lanatus*
PI 368516	2	Yugoslavia	*Citrullus lanatus*
PI 368519	2	Yugoslavia	*Citrullus lanatus*
PI 379225	2	Yugoslavia	*Citrullus lanatus*
PI 379234	2	Yugoslavia	*Citrullus lanatus*
PI 379235	2	Yugoslavia	*Citrullus lanatus*
PI 379236	2	Yugoslavia	*Citrullus lanatus*

Table 2.4 continued

PI 500329	2	Zambia	*Citrullus lanatus*
PI 225557	2	Zimbabwe	*Citrullus lanatus*
PI 482247	2	Zimbabwe	*Citrullus lanatus*
PI 482249	2	Zimbabwe	*Citrullus lanatus*
PI 482262	2	Zimbabwe	*Citrullus lanatus*
PI 386024	2	Iran	*C. colocynthis*
PI 537300	2	Turkmenistan	*C. colocynthis*
PI 542118	2	Botswana	*C. lanatus* var. *citroides*
PI 296341	2	South Africa	*C. lanatus* var. *citroides*
PI 482276	2	Zimbabwe	*C. lanatus* var. *citroides*
PI 482283	2	Zimbabwe	*C. lanatus* var. *citroides*
PI 485579	2	Zimbabwe	*C. lanatus* var. *citroides*
PI 254430	3	Lebanon	*Citrullus lanatus*
PI 211011	4	Afghanistan	*Citrullus lanatus*
PI 459074	4	Botswana	*Citrullus lanatus*
PI 542119	4	Botswana	*Citrullus lanatus*
PI 542120	4	Botswana	*Citrullus lanatus*
PI 542121	4	Botswana	*Citrullus lanatus*
PI 549160	4	Chad	*Citrullus lanatus*
Grif 12335	4	China	*Citrullus lanatus*
PI 532819	4	China	*Citrullus lanatus*
PI 593344	4	China	*Citrullus lanatus*
PI 183217	4	Egypt	*Citrullus lanatus*
PI 273479	4	Ethiopia	*Citrullus lanatus*
PI 306364	4	Gabon	*Citrullus lanatus*
PI 270141	4	India	*Citrullus lanatus*
PI 271363	4	India	*Citrullus lanatus*
PI 381747	4	India	*Citrullus lanatus*
PI 386016	4	Iran	*Citrullus lanatus*
PI 386019	4	Iran	*Citrullus lanatus*
PI 386021	4	Iran	*Citrullus lanatus*
PI 386025	4	Iran	*Citrullus lanatus*
PI 254428	4	Lebanon	*Citrullus lanatus*
PI 536457	4	Maldives	*Citrullus lanatus*
PI 536461	4	Maldives	*Citrullus lanatus*
PI 490377	4	Mali	*Citrullus lanatus*

Table 2.4 continued

PI 490383	4	Mali	*Citrullus lanatus*
PI 490384	4	Mali	*Citrullus lanatus*
PI 632751	4	Namibia	*Citrullus lanatus*
PI 494530	4	Nigeria	*Citrullus lanatus*
PI 559995	4	Nigeria	*Citrullus lanatus*
PI 271988	4	Somalia	*Citrullus lanatus*
PI 596667	4	South Africa	*Citrullus lanatus*
PI 167219	4	Turkey	*Citrullus lanatus*
PI 169267	4	Turkey	*Citrullus lanatus*
PI 169289	4	Turkey	*Citrullus lanatus*
PI 178870	4	Turkey	*Citrullus lanatus*
PI 182176	4	Turkey	*Citrullus lanatus*
PI 278010	4	Turkey	*Citrullus lanatus*
PI 278036	4	Turkey	*Citrullus lanatus*
PI 278060	4	Turkey	*Citrullus lanatus*
DMR-112	4	United States	*Citrullus lanatus*
Moon and Stars	4	United States	*Citrullus lanatus*
PI 556995	4	United States	*Citrullus lanatus*
Red-N-Sweet	4	United States	*Citrullus lanatus*
Sugar Loaf	4	United States	*Citrullus lanatus*
Tom Watson	4	United States	*Citrullus lanatus*
PI 502318	4	Uzbekistan	*Citrullus lanatus*
PI 266015	4	Venezuela	*Citrullus lanatus*
PI 357702	4	Yugoslavia	*Citrullus lanatus*
PI 500324	4	Zambia	*Citrullus lanatus*
PI 482279	4	Zimbabwe	*Citrullus lanatus*
PI 374216	4	Afghanistan	*C. colocynthis*
Grif 14201	4	India	*C. colocynthis*
PI 386014	4	Iran	*C. colocynthis*
PI 542113	4	Botswana	*C. lanatus* var. *citroides*
PI 542117	4	Botswana	*C. lanatus* var. *citroides*
PI 288316	4	India	*C. lanatus* var. *citroides*
PI 295845	4	South Africa	*C. lanatus* var. *citroides*
PI 505604	4	Zambia	*C. lanatus* var. *citroides*
PI 381745	6	India	*Praecitrullus fistulosus*
PI 271748	6	Afghanistan	*Citrullus lanatus*

Table 2.4 continued

PI 346082	6	Afghanistan	*Citrullus lanatus*
PI 269681	6	Belize	*Citrullus lanatus*
PI 542116	6	Botswana	*Citrullus lanatus*
PI 593340	6	China	*Citrullus lanatus*
PI 593343	6	China	*Citrullus lanatus*
PI 273480	6	Ethiopia	*Citrullus lanatus*
PI 507866	6	Hungary	*Citrullus lanatus*
PI 271468	6	India	*Citrullus lanatus*
PI 381713	6	India	*Citrullus lanatus*
PI 222710	6	Iran	*Citrullus lanatus*
PI 226460	6	Iran	*Citrullus lanatus*
PI 270523	6	Israel	*Citrullus lanatus*
PI 385963	6	Kenya	*Citrullus lanatus*
PI 254744	6	Senegal	*Citrullus lanatus*
PI 271986	6	Somalia	*Citrullus lanatus*
PI 274034	6	South Africa	*Citrullus lanatus*
PI 596679	6	South Africa	*Citrullus lanatus*
PI 596687	6	South Africa	*Citrullus lanatus*
PI 314236	6	Soviet Union	*Citrullus lanatus*
PI 512340	6	Spain	*Citrullus lanatus*
PI 537473	6	Spain	*Citrullus lanatus*
PI 271132	6	Tunisia	*Citrullus lanatus*
PI 271133	6	Tunisia	*Citrullus lanatus*
PI 169266	6	Turkey	*Citrullus lanatus*
PI 172804	6	Turkey	*Citrullus lanatus*
PI 177321	6	Turkey	*Citrullus lanatus*
PI 277991	6	Turkey	*Citrullus lanatus*
PI 278033	6	Turkey	*Citrullus lanatus*
PI 344300	6	Turkey	*Citrullus lanatus*
PI 595219	6	United States	*Citrullus lanatus*
PI 629111	6	United States	*Citrullus lanatus*
PI 476327	6	Uzbekistan	*Citrullus lanatus*
PI 502317	6	Uzbekistan	*Citrullus lanatus*
PI 357714	6	Yugoslavia	*Citrullus lanatus*
PI 368511	6	Yugoslavia	*Citrullus lanatus*
PI 378612	6	Zaire	*Citrullus lanatus*

PI 500355	6	Zambia	*Citrullus lanatus*
PI 482259	6	Zimbabwe	*Citrullus lanatus*
PI 482266	6	Zimbabwe	*Citrullus lanatus*
PI 482299	6	Zimbabwe	*Citrullus lanatus*
PI 482301	6	Zimbabwe	*Citrullus lanatus*
PI 482302	6	Zimbabwe	*Citrullus lanatus*
PI 482338	6	Zimbabwe	*Citrullus lanatus*
Grif 16374	6	France	*C. rehmii*
Grif 16376	6	France	*C. rehmii*
PI 271767	6	South Africa	*C. lanatus* var. *citroides*

Table 2.5. F ratio and coefficient of variation for mean of bacterial fruit blotch ratings on watermelon taken at 1st, 2nd, 3rd times during germplasm screening for resistance to Group II bacterial fruit blotch strains from 2011 to 2013 in Clinton, NC, USA.

Trait	Mean Square	F ratio	R^2(%)	CV
Mean of all ratings†	3.79	4.12***	81	19.69
Mean of 1st ratings‡	5.83	2.83***	76	39.67
Mean of 2nd ratings§	4.18	2.95***	82	24.30
Mean of 3rd ratings¶	5.17	3.94***	80	18.70

*** Significant at level of 0.0001of probability
†Mean of 1st, 2nd, and 3rd ratings from all 3 years of 2011 to 2013.
‡The first rating for 2011 and 2012 started at the 8th week after planting, and the first rating for 2013 started at the 3rd week after planting, 1 week after inoculation.
§The second rating for 2011 and 2012 started at the 9th week after planting, and the second rating for 2013 started at the 4th week after planting, 2 weeks after inoculation.
¶The third rating for 2011 and 2012 started at the 10th week after planting, and the third rating for 2013 started at the 3rd week after planting, 3 weeks after inoculation.

Table 2.6. Analysis of variance for the mean of all ratings on bacterial fruit blotch foliar symptom during watermelon germplasm screening from 2011 to 2013.

a

Source of variation	df	Mean square	F ratio
Year	2	3544.30	26.7*
Block	3	132.71	
Cultigen	1654	3.79	4.1***
Cultigen x Year	3000	1.66	1.8***
Error	4644	0.92	

b

Source of variation	df	Mean Square	F ratio
Replication	5	1497.34	1235.0***
Cultigen	1654	3.79	3.1***
Error	7644	1.21	

*** Significant at level of 0.0001of probability; ** Significant at level of 0.001 of probability; * Significant at level of 0.05 of probability.

Table 2.7. Analysis of variance for the mean of best ratings[†] on bacterial fruit blotch foliar symptom during watermelon germplasm screening from 2011 to 2013.

a

Source of variation	df	Mean Square	F ratio
Year	2	3966.97	27.7*
Block (Year)	3	143.38	
Cultigen	1654	5.17	4.0***
Cultigen x Year	2992	2.33	1.8***
Error	4575	1.31	

b

Source of variation	df	Mean Square	F ratio
Rep	5	1672.81	977.4***
Cultigen	1654	5.17	3.0***
Error	7567	1.71	

*** Significant at level of 0.0001of probability; ** Significant at level of 0.001 of probability; * Significant at level of 0.05 of probability.
[†] Best rating was defined as the third time rating for each year.

Table 2.8. Most resistant and susceptible cultigens to bacterial fruit blotch Group II strains and their overall means, means of the best ratings, means of maximum ratings, standard deviation and number of replication for 3rd ratings and the means of 1st, 2nd, and 3rd ratings over 2011 to 2013.

		Bacterial fruit blotch rating						
Cultigen	Seed source	Ave. †	Max‡	SD§	No. ¶	1st #	2nd	3rd
Resistant								
PI 482246	Zimbabwe	2.4	4	0	3	1.7	2.7	3
PI 482273	Zimbabwe	2.5	7	0	4	1.8	2.7	3
PI 482322	Zimbabwe	2.8	6.0	0.7	5	2.3	3.2	3.0
PI 596666	South Africa	2.8	7.0	1.4	5	2.2	3.2	3.2
PI 532670	Zimbabwe	2.9	6.0	0.0	3	2.3	3.0	3.3
PI 271770	South Africa	3.2	6.0	0.0	4	2.7	3.7	3.3
PI 482300	Zimbabwe	3.5	7.0	0.0	5	3.0	4.2	3.3
PI 482277	Zimbabwe	2.9	6.0	0.7	5	2.0	3.3	3.5
PI 482309	Zimbabwe	3.3	6.0	1.4	6	2.8	3.5	3.5
PI 596665	South Africa	3.2	9.0	0.0	6	2.2	3.8	3.5
PI 500331	Zambia	2.8	6.0	0.7	5	1.3	3.5	3.7
PI 596668	South Africa	3.3	6.0	0.7	5	2.5	3.8	3.7
PI 560006	Nigeria	2.8	7.0	3.5	6	1.8	2.8	3.7
PI 296337	South Africa	2.7	5.0	0.0	5	1.7	2.5	3.8
PI 482274	Zimbabwe	3.1	6.0	0.7	5	2.0	3.5	3.8
PI 500354	Zambia	3.3	6.0	0.7	5	2.7	3.3	3.8
PI 532664	Zimbabwe	3.3	7.0	0.0	5	2.3	3.7	3.8
PI 482318	Zimbabwe	3.0	7.0	0.0	6	1.5	3.7	3.8
PI 482333	Zimbabwe	3.5	7.0	1.4	6	2.8	3.8	3.8
PI 595201	United States	3.2	6.0	0.0	6	2.7	3.0	3.8
PI 482303	Zimbabwe	3.4	8.0	0.7	5	2.5	3.8	4.0
PI 482311	Zimbabwe	3.3	7.0	1.4	5	2.0	3.8	4.0
PI 595203	United States	2.8	6.0	0.7	5	1.3	3.0	4.2
PI 596696	South Africa	3.3	6.0	1.4	5	2.0	3.8	4.2
PI 296342	South Africa	2.8	5.0	0.7	6	1.7	2.5	4.2
PI 482367	Zimbabwe	2.9	6.0	0.0	6	1.3	3.3	4.2
PI 500328	Zambia	3.3	8.0	0.0	6	2.0	3.7	4.2
PI 500332	Zambia	3.3	8.0	1.4	6	2.2	3.5	4.2
PI 299379	South Africa	3.4	6.0	0.0	4	2.2	3.7	4.3
PI 271779	South Africa	3.4	5.0	0.7	5	3.2	2.8	4.3

Table 2.8 continued

PI 596656	South Africa	3.5	6.0	0.0	5	2.3	3.8	4.3
PI 596659	South Africa	3.4	7.0	1.4	5	2.3	3.7	4.3
Grif 15897	Russia	3.4	8.0	0.7	6	2.0	3.8	4.3
PI 248774	Namibia	3.4	7.0	0.7	6	2.7	3.2	4.3
PI 482355	Zimbabwe	3.2	7.0	1.4	6	1.3	4.0	4.3
PI 596653	South Africa	3.5	7.0	0.7	6	3.2	3.0	4.3
PI 295843	South Africa	3.1	7.0	0.7	3	1.7	3.3	4.3
PI 560901	China	2.9	9.0	0.0	4	1.5	2.8	4.5
PI 244017	South Africa	3.2	7.0	2.1	5	1.8	3.3	4.5
PI 532667	Zimbabwe	3.4	7.0	0.7	5	1.8	4.0	4.5
PI 560000	Nigeria	3.2	6.0	0.0	6	1.7	3.5	4.5
PI 482261	Zimbabwe	3.4	7.0	2.8	4	1.5	4.0	4.7
PI 482278	Zimbabwe	3.4	8.0	0.7	5	1.3	4.2	4.7
PI 500301	Zambia	3.3	7.0	0.7	5	1.8	3.5	4.7
PI 296343	South Africa	3.1	5.0	0.0	6	1.7	3.0	4.7
PI 482272	Zimbabwe	3.2	7.0	2.1	6	1.8	3.0	4.7
PI 482342	Zimbabwe	3.4	7.0	1.4	6	2.0	3.5	4.7
PI 494531	Nigeria	3.5	7.0	0.7	6	1.8	4.0	4.7
PI 500320	Zambia	3.4	8.0	2.8	6	2.3	3.3	4.7
PI 500321	Zambia	3.3	7.0	2.1	5	2.2	3.0	4.8
PI 500303	Zambia	3.4	7.0	0.0	6	2.0	3.5	4.8
PI 560023	Nigeria	2.9	7.0	0.7	6	1.0	3.0	4.8
PI 595202	United States	3.4	7.0	1.4	6	2.2	3.3	4.8
PI 500340	Zambia	3.1	6.0	0.7	6	1.3	2.8	5.0
PI 249008	Nigeria	3.5	9.0	0.0	5	1.7	3.7	5.2
PI 560014	Nigeria	3.3	7.0	0.7	6	1.0	3.7	5.2
PI 296341	South Africa	3.4	6.0	0.0	3	1.8	3.3	5.3
PI 296339	South Africa	3.3	6.0	1.4	4	1.7	3.0	5.3
PI 482264	Zimbabwe	3.3	7.0	1.4	5	0.7	3.7	5.5
PI 512348	Spain	3.3	9.0	0.7	5	0.8	3.5	5.5
PI 560010	Nigeria	3.4	7.0	0.0	5	1.2	3.7	5.5
PI 595200	United States	3.5	8.0	2.1	6	1.5	3.5	5.5
Checks								
Jubilee	United States	2	4	0.7	2	1.5	1	3.5
Peacock Shipper	United States	4.4	7	0	5	3.3	4.3	5.5
Allsweet	United States	3.8	7	0	3	2.3	3.3	6

Table 2.8 continued

Georgia Rattlesnake	United States	4.1	7	0.7	3	3	4	6.3
Crimson Sweet	United States	5.7	8	0.7	4	4.7	6	6.6
Minilee	United States	5.3	9	0.7	5	4.2	5.5	6.6
Congo	United States	6.5	9	2.1	3	6.3	6.3	6.7
Mickylee	United States	5	9	2.1	6	3.2	5.2	6.7
Charleston Gray	United States	4.8	9	0.7	5	3.8	4.7	6.8
Calhoun Gray	United States	4.8	9	0	5	2.8	4.8	6.8
Golden Midget	United States	5.3	9	1.4	3	4.8	5	7.3
Black Diamond YB	United States	6	8	0	3	5	5.5	7.5
Sugar Baby	United States	6.1	9	0	4	4.8	5.8	7.8
Stone Mountain	United States	6.5	9	1.4	4	4.8	6.8	8
Susceptible								
PI 525090	Egypt	5.9	9	0	5	3.3	6	8.5
PI 536459	Maldives	7.4	9	0	5	6	7.8	8.5
PI 212288	Afghanistan	6.8	9	0	4	4.8	6.8	8.8
PI 357725	Yugoslavia	6.6	9	0.7	4	4.3	6.8	8.8
PI 357751	Yugoslavia	8	9	0	4	7.3	8	8.8
PI 536454	Maldives	6.7	9	0	4	6	7	8.8
PI 183217	Egypt	9	9	0	1	9	9	9
PI 278036	Turkey	9	9	0	1	9	9	9
PI 386021	Iran	4.7	9	0	1	0	5	9
PI 559995	Nigeria	9	9	0	1	9	9	9
PI 632751	Namibia	9	9	0	1	9	9	9
PI 536461	Maldives	9	9	.	2	9	9	9
PI 559994	Nigeria	7.7	9	0	2	6	8	9
PI 536462	Maldives	8.2	9	0	3	7.7	7.8	9
PI 536464	Maldives	7.3	9	0	3	5.7	7.3	9
PI 183398	India	6.8	9	0	4	4.3	7.3	9
PI 536463	Maldives	7.6	9	0	4	6.3	7.3	9

†Mean of all ratings over 3 years from 2011 to 2013.
‡ Mean of the maximum ratings over 3 years from 2011 to 2013.
§ Standard deviation
¶ Number of replications in 3rd ratings
# 1st 2011 and 2012 started at the 8th week after planting, and the first rating for 2013 started at the 3rd week after planting, 1 week after inoculation; 2nd for 2011 and 2012 started at the 9th week after planting, and the second rating for 2013 started at the 4th week after planting, 2

Table 2.8 continued

weeks after inoculation; 3rd for 2011 and 2012 started at the 10th week after planting, and the third rating for 2013 started at the 5th week after planting, 3 weeks after inoculation; equals to the mean of best ratings over 3 years from 2011 to 2013.

Table 2.9. List of resistant cultigens (with seed source and species/variety) from 2011 screening and their mean of besting ratings in 2012 retest and in 2011 to 2013 screening.

Cultigen	Seed Source	Species /variety	2011 mean	2012 retest†	2012 mean	2013 mean
Resistant						
PI 271770	South Africa	*C.* var. *citroides*	2.0	2.0	6.0	2.0
PI 482246	Zimbabwe	*Citrullus lanatus*	2.0	-	3.0	4.0
PI 532670	Zimbabwe	*C. var. citroides*	2.0	-	6.0	2.0
PI 596666	South Africa	*C.* var. *citroides*	2.5	3.0	3.0	4.0
PI 482274	Zimbabwe	*Citrullus lanatus*	3.0	4.0	5.5	3.0
PI 482324	Zimbabwe	*C. var. citroides*	3.0	3.5	3.5	4.0
PI 482331	Zimbabwe	*C. var. citroides*	3.0	3.0	4.5	3.0
PI 596692	South Africa	*C. var. citroides*	3.0	4.0	-	6.0
PI 482272	Zimbabwe	*Citrullus lanatus*	3.5	4.3	5.5	5.0
PI 482319	Zimbabwe	*C. var. citroides*	3.5	4.0	3.5	5.0
PI 482342	Zimbabwe	*C.* var. *citroides*	3.5	5.8	6.0	4.5
PI 482367	Zimbabwe	*Citrullus lanatus*	3.5	4.0	5.0	4.0
PI 596668	South Africa	*C. var. citroides*	3.5	3.8	3.5	4.0
PI 482277	Zimbabwe	*C.* var. *citroides*	4.0	3.8	3.5	3.0
PI 296342	South Africa	*C. var. citroides*	4.5	3.7	3.5	4.5
PI 482293	Zimbabwe	*C. var. citroides*	4.5	4.5	5.0	4.0
PI 560019	Nigeria	*Citrullus lanatus*	5.0	4.3	-	-
Checks						
Calhoun Gray	United States	*Citrullus lanatus*	8.5	5.3	8.5	4.0
Mickylee	United States	*Citrullus lanatus*	8.5	5.5	6.5	5.0
Crimson Sweet	United States	*Citrullus lanatus*	7.0	5.0	7.5	4.0
Susceptible						
PI 164665	India	*Citrullus lanatus*	9.0	6.5	8.5	6.0
PI 525100	Italy	*Citrullus lanatus*	9.0	6.3	6.5	6.5
LSD (0.05)			2.0	1.3	2.1	2.0

† The correlation coefficients between 2011 retest and 2011, 2012, 2013 screening were 0.83, 0.65, and 0.71 respectively (significant at level of 0.001 probability).

Table 2.10. List of resistant cultigens (with seed source and species/variety) from 2012 screening, their mean of besting ratings in 2013 retest and in 2012 to 2013 screening, and plant size measured in 2013.

Cultigen	Seed source	Species/ variety	BFB rating 2012 mean	BFB rating 2013 mean	BFB rating 2013 retest[†]	Plant Size 2013 mean[‡]
Resistant						
PI 482246	Zimbabwe	*Citrullus lanatus*	1.3	4.0	1.5	3.8
PI 596669	South Africa	*C. var. citroides*	2.5	4.0	2.3	3.3
PI 482309	Zimbabwe	*C. var. citroides*	3.0	5.0	2.0	4.0
PI 596665	South Africa	*C. var. citroides*	3.0	3.5	2.3	4.3
PI 532738	Zaire	*C. var. citroides*	3.0	5.0	2.3	4.5
PI 271770	South Africa	*C. var. citroides*	3.3	2.0	2.5	1.8
PI 482324	Zimbabwe	*C. var. citroides*	3.5	4.0	2.3	3.5
PI 482265	Zimbabwe	*C. var. citroides*	3.5	5.0	1.8	4.3
PI 482319	Zimbabwe	*C. var. citroides*	3.5	5.0	2.0	3.8
PI 596668	South Africa	*C. var. citroides*	3.5	4.0	1.5	4.0
PI 482277	Zimbabwe	*C. var. citroides*	3.5	3.0	2.0	3.3
PI 500354	Zambia	*C. var. citroides*	3.5	4.0	1.8	3.8
PI 596666	South Africa	*C. var. citroides*	4.0	3.5	1.0	3.5
PI 482284	Zimbabwe	*Citrullus lanatus*	4.5	5.0	1.8	3.8
PI 482322	Zimbabwe	*C. var. citroides*	4.5	2.5	1.0	4.0
PI 482331	Zimbabwe	*C. var. citroides*	4.5	3.0	1.3	4.8
PI 482283	Zimbabwe	*C. var. citroides*	4.5	.	1.3	3.5
PI 485583	Botswana	*C. var. citroides*	5.0	3.5	1.8	3.8
PI 482252	Zimbabwe	*C. var. citroides*	5.0	3.5	1.8	4.3
PI 482342	Zimbabwe	*C. var. citroides*	6.0	4.5	1.3	3.8
Check						
Charleston Gray	United States	*Citrullus lanatus*	6.5	5.0	3.0	3.5
Susceptible						
PI 635598	United States	*Citrullus lanatus*	8.0	6.0	4.8	2.3
LSD (0.05)			2.1	2.0	1.1	1.3

[†] The correlation coefficients between 2011 retest and 2011, 2012, 2013 screening were 0.82, 0.49, and 0.61, respectively (significant at level of 0.001 probability).
[‡] Plant size was rated on a 1-5 scale (with 1 as the smallest and 5 as the largest). Data were collected in 2013 retest on June 24, 2013, 6 weeks after planting.

Table 2.11. Rating variability on selected resistant, susceptible cultigens, and cultivar checks over the year of 2011 to 2013 and replication (with seed source).

		Bacterial fruit blotch rating								
Cultigen	Seed source	Mean	Best	Max.	1st	2nd	3rd	4th	5th	6th
Resistant										
PI 482246	Zimbabwe	2.4	3.0	3.3	2	2	3	3	4	4
PI 482273	Zimbabwe	2.5	3.0	3.8	5	5	4	4	0	0
PI 482322	Zimbabwe	2.8	3.0	4.3	2	2	4	5	3	2
PI 596666	South Africa	2.8	3.2	4.5	4	1	2	4	4	4
PI 271770	South Africa	3.2	3.3	4.7	2	2	6	6	2	2
PI 482300	Zimbabwe	3.5	3.3	4.3	5	4	3	3	2	3
PI 532670	Zimbabwe	2.9	3.3	4.7	2	2	6	6	2	2
PI 482277	Zimbabwe	2.9	3.5	4.0	5	3	4	3	3	3
PI 596665	South Africa	3.2	3.5	4.3	4	4	3	3	4	3
PI 500331	Zambia	2.8	3.7	4.0	4	5	4	3	3	3
PI 560006	Nigeria	2.8	3.7	4.2	2	6	2	7	2	3
PI 596668	South Africa	3.3	3.7	4.3	4	3	3	4	4	4
PI 296337	South Africa	2.7	3.8	3.8	5	4	5	5	2	2
PI 482318	Zimbabwe	3.0	3.8	4.3	7	3	4	4	5	0
PI 500354	Zambia	3.3	3.8	4.3	5	3	4	3	4	4
PI 595201	United States	3.2	3.8	4.5	3	4	4	4	4	4
PI 482311	Zimbabwe	3.3	4.0	4.5	5	5	4	2	4	4
PI 296342	South Africa	2.8	4.2	4.3	5	4	3	4	4	5
PI 482367	Zimbabwe	2.9	4.2	4.7	6	1	5	5	4	4
PI 500328	Zambia	3.3	4.2	4.3	5	8	4	4	3	1
PI 500332	Zambia	3.3	4.2	5.0	6	3	5	3	3	5
PI 596696	South Africa	3.3	4.2	4.5	4	6	2	4	5	4
PI 271779	South Africa	3.4	4.3	4.3	5	5	4	5	4	3
PI 536463	Maldives	7.6	9.0	9.0	9	9	9	9	9	9
PI 183398	India	6.8	9.0	9.0	9	9	9	9	8	9
PI 357725	Yugoslavia	6.6	8.8	8.8	9	9	9	8	8	9
PI 222715	Iran	7.1	8.5	8.5	9	7	9	9	8	9
Checks										
Charleston Gray	United States	5.1	6.7	6.7	9	7	7	6	5	6
Mickylee	United States	5.0	6.7	6.7	8	9	8	5	5	5

‡ Mean of the best ratings over 2011 to 2013.

Table 2.11 continued

§ Mean of all the ratings over 2011 to 2013.

¶ Mean of the maximum ratings over 2011 to 2013.

†† 1st is the mean of all the ratings taken at the 8th week after planting in 2011 and 2012 and at the 1st week after inoculation in 2013; 2nd is the mean of all the ratings taken at the 9th week after planting in 2011 and 2012 and at the 2nd week after inoculation in 2013; 3rd is the mean of all the ratings taken at the 10th week after planting in 2011 and 2012 and at the 3rd week after inoculation in 2013.

Table 2.12. Pearson correlation coefficient (above diagonal) and Spearman correlation coefficient (below diagonal) of mean of 1st, 2nd and 3rd bacterial fruit blotch ratings from 2011to 2013 screening. [†]

	Best[‡]	Ave.[§]	Max[¶]	1st[††]	2nd	3rd
Best	1.00	0.83 ***	0.92 ***	0.49 ***	0.69 ***	1.00 ***
Ave.	0.82 ***	1.00	0.87 ***	0.86 ***	0.92 ***	0.83 ***
Max	0.91 ***	0.86 ***	1.00	0.58 ***	0.77 ***	0.92 ***
1st	0.48 ***	0.84 ***	0.56 ***	1.00	0.73 ***	0.49 ***
2nd	0.68 ***	0.89 ***	0.75 ***	0.66 ***	1.00	0.69 ***
3rd	1.00 ***	0.82 ***	0.91 ***	0.48 ***	0.68 ***	1.00

*** Significant at level of 0.0001of probability.

[†] Data were summarized on 6 replications over 2011 to 2013 screening.

[‡] Mean of the best ratings over 2011 to 2013.

[§] Mean of all the ratings over 2011 to 2013.

[¶] Mean of the maximum ratings over 2011 to 2013.

[††] 1st is the mean of all the ratings taken at the 8th week after planting in 2011 and 2012 and at the 1st week after inoculation in 2013; 2nd is the mean of all the ratings taken at the 9th week after planting in 2011 and 2012 and at the 2nd week after inoculation in 2013; 3rd is the mean of all the ratings taken at the 10th week after planting in 2011 and 2012 and at the 3rd week after inoculation in 2013.

Table 2.13. Pearson correlation coefficient of mean of 1st, 2nd, 3rd rating from each year of 2011 to 2013.

		2011 screening		2012 screening			2013 screening		
		2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
2011	1st [†]	0.35 ***	0.25 ***	0.12 ***	0.13 ***	0.16 ***	0.14 ***	0.11 ***	0.14 ***
	2nd	1.00	0.57 ***	0.14 ***	0.20 ***	0.23 ***	0.14 ***	0.08 *	0.10 **
	3rd		1.00	0.19 ***	0.28 ***	0.31 ***	0.18 ***	0.13 ***	0.15 ***
2012	1st			1.00	0.81 ***	0.48 ***	0.17 ***	0.15 ***	0.21 ***
	2nd				1.00	0.68 ***	0.21 ***	0.15 ***	0.23 ***
	3rd					1.00	0.24 ***	0.16 ***	0.23 ***
2013	1st						1.00	0.52 ***	0.32 ***
	2nd							1.00	0.59 ***

*** indicating significant at 0.0001 level; ** indicating significant at 0.001 level; and * indicating significant at 0.01 level.

[†] 1st is the mean of all the ratings taken at the 8th week after planting in 2011 and 2012 and at the 1st week after inoculation in 2013; 2nd is the mean of all the ratings taken at the 9th week after planting in 2011 and 2012 and at the 2nd week after inoculation in 2013; 3rd is the mean of all the ratings taken at the 10th week after planting in 2011 and 2012 and at the 3rd week after inoculation in 2013.

Table 2.14. Pearson correlation coefficient (above diagonal) and Spearman correlation coefficient (below diagonal) of mean of 1st, 2nd and 3rd bacterial fruit blotch ratings on 8 PI† accessions that were retested in 2012 to 2013.

		2012 retest			2013 retest	
		1st †	2nd	3rd	1st	2nd
2012	1st	1.00	0.89	0.55	0.41	0.14
			***	0.16	0.31	0.74
	2nd	0.94	1.00	0.59	0.27	0.18
		***		0.12	0.52	0.67
	3rd	0.66	0.64	1.00	-0.10	0.04
		**	**		0.81	0.93
2013	1st	0.27	0.40	-0.06	1.00	0.72
		0.52	0.33	0.90		***
	2nd	0.10	0.27	0.23	0.72	1.00
		0.82	0.52	0.59	***	

*** Significant at level of 0.0001of probability; ** Significant at level of 0.001 of probability.

† 8 Plant Introduction accessions were in both 2012 and 2013 retest: PI 271770, PI 482277, PI 482319, PI 482324, PI 482331, PI 596666, PI 596668, and PI 635598.

‡ 1st is the mean of all the ratings taken at the 8th week after planting in 2011 and 2012 and at the 1st week after inoculation in 2013; 2nd is the mean of all the ratings taken at the 9th week after planting in 2011 and 2012 and at the 2nd week after inoculation in 2013; 3rd is the mean of all the ratings taken at the 10th week after planting in 2011 and 2012.

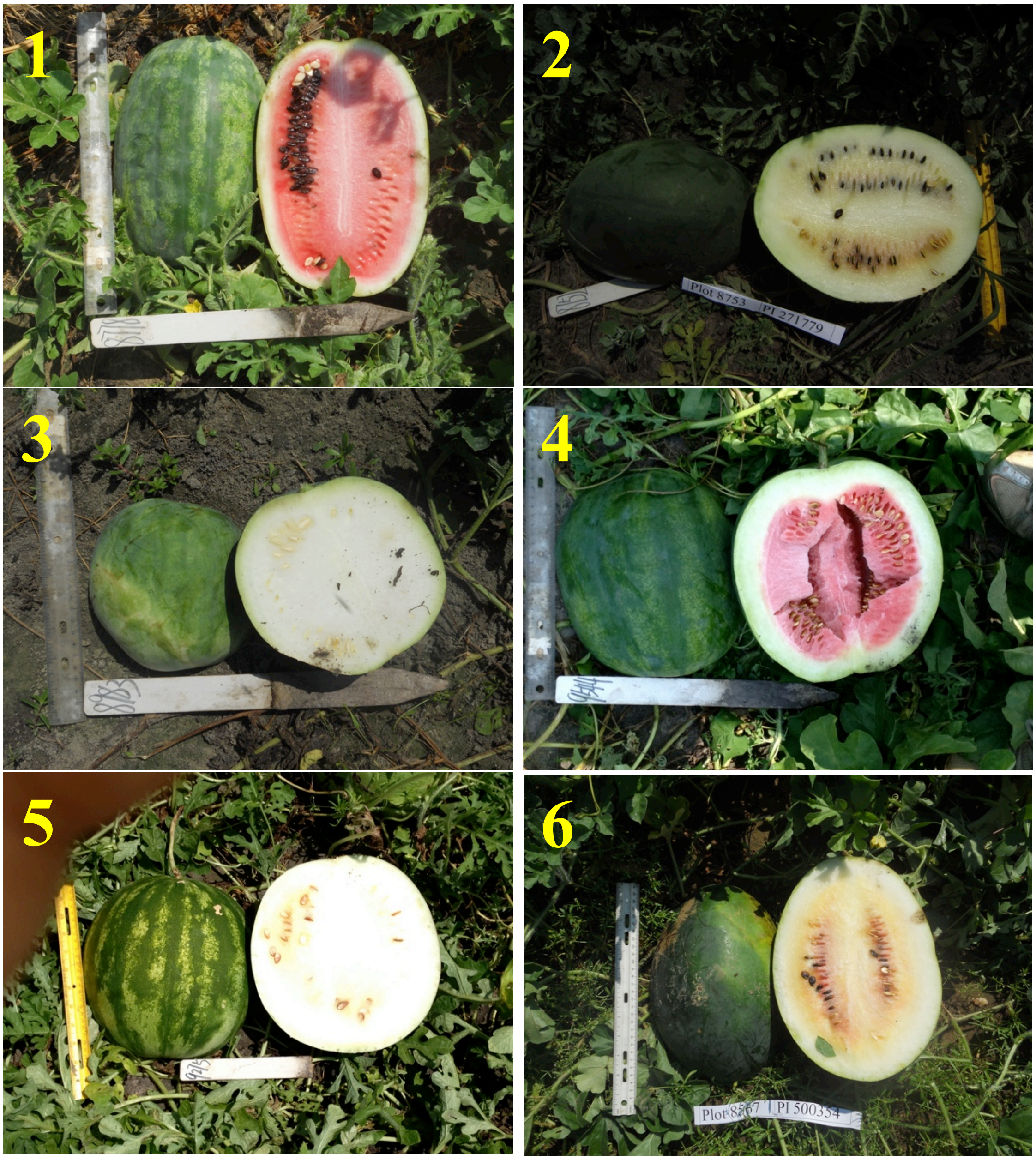
1
2
Plot 8753 PI 271779
3
4
5
6

Fig. 2.1 continued

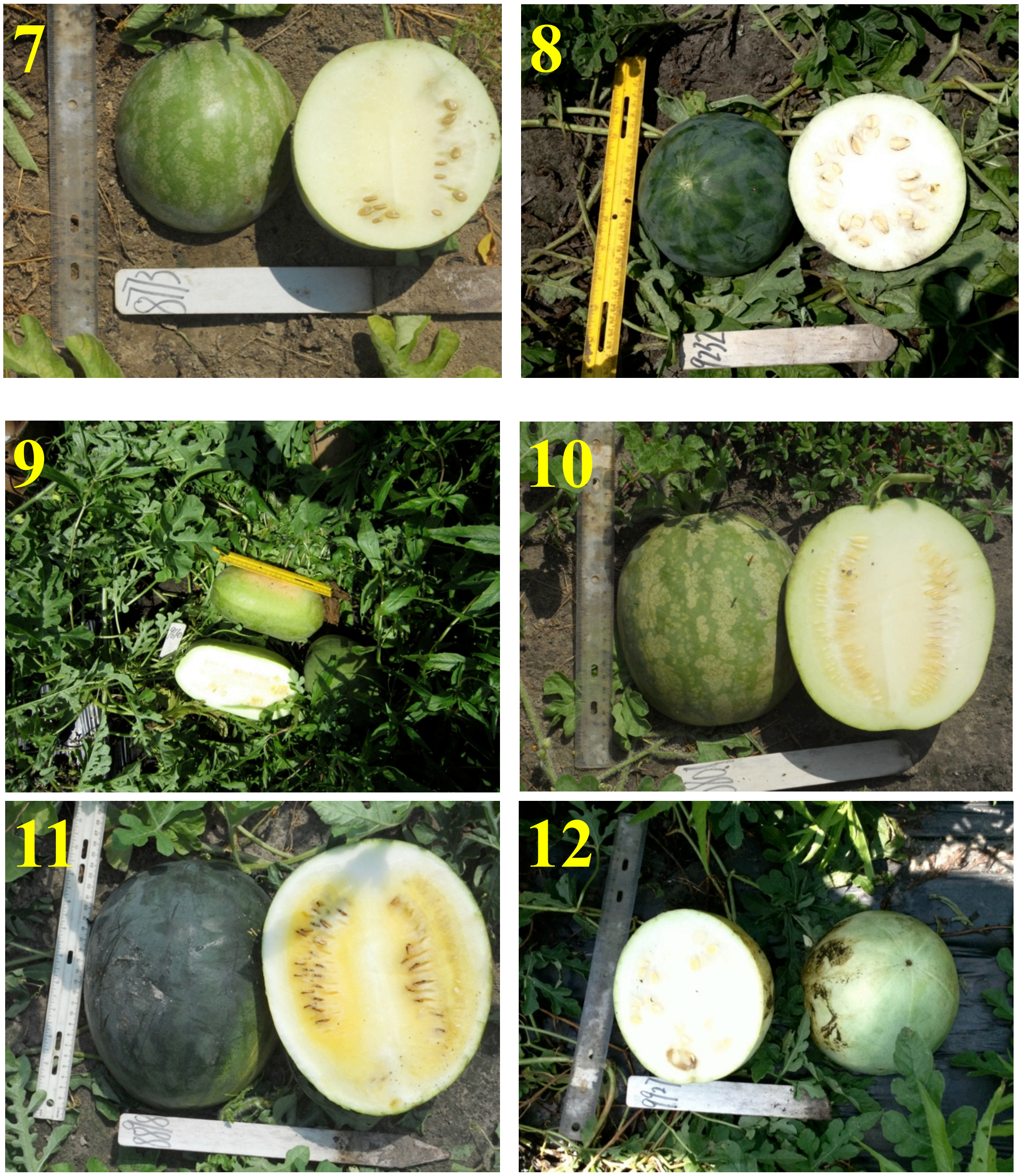

Fig. 2.1. Watermelon photographs showing flesh color, rind color, rind pattern, seed color on selected 12 resistant PI accessions. (Photographs were taken on Aug 15, 2013 at Clinton, NC). Photographs 1-12 are PI 271770, PI 271779, PI 482277, PI 482300, PI 500328, PI 500354, PI 532670, PI 560008, PI 596665, PI 596668, PI 596669, and PI 595203 respectively.

CHAPTER 3 Leaf Surface Physical Characteristics of Four Watermelon Species and Their Impact on Bacterial Fruit Blotch Resistance

ABSTRACT

Cucurbit bacterial fruit blotch caused by *Acidovorax avenue* subsp. *citrulli* is a significant threat to watermelon [*Citrullus lanatus* (Thunb.) Matsum. and Nakai] production worldwide. In the United States, seedless cultivars are primarily used in watermelon production, and thus rely largely on transplant production in greenhouses to ensure a high germination rate. Unfortunately, the warm and humid greenhouse environment provides ideal conditions for the spread of bacterial fruit blotch. Treatments designed to remove bacteria from the surface of the seed coat were investigated previously, but none eliminated the bacteria despite their significant effects in research studies. Resistant cultivars offer a solution to the problem if sources of resistance can be identified. Understanding the disease symptoms caused by bacterial fruit blotch on different Citrullus species can improve the effectiveness of screening for resistance in the field and greenhouse. Therefore, the objectives of this research were to study the impact of density of trichomes and stomates on symptoms caused by bacterial fruit blotch and the influence of leaf surface structure on plant response to bacterial fruit blotch among accessions belonging to 4 four different Citrullus species or varieties in the USDA watermelon germplasm collection. We used scanning electronic microscopy to investigate trichome and stomate density, stomatal aperture, and distribution of bacteria on lightly vs. heavily infected leaf tissues. The accessions were PI

482246 (*Citrullus lanatus*), PI 381746 (*Praecitrullus fistulosus*), PI 368527 (*C. lanatus*), PI 482331 (*C. lanatus var. citroides*), Grif 16135 (*C. lanatus var. citroides* (formerly classified as *C. rehmii*). The results revealed that both trichomes and stomates are common areas for bacterial colonization and that stomatal aperture could be used as a resistance trait for bacterial fruit blotch screening in watermelon.

1. INTRODUCTION

Watermelon ([*Citrullus lanatus* (Thunb.) Matsum. and Nakai]) belongs to the Cucurbitaceae and is one of most economically important cucurbit crops. It has been threatened by bacterial fruit blotch (*Acidovorax avenae* subsp. *citrulli*) commercially since 1989 in the United States (Hopkins, 1989). Due to ineffective disease control treatments, genetic resistance could be an effective strategy for controlling bacterial fruit blotch. In addition to cost effectiveness, resistance-based strategies are compatible with other integrated disease management approaches. However, resistant cultivars have not been developed so far (Hopkins and Levi, 2008), even though resistance has been identified in PI 482279 and PI 494817.

Breeding for resistance may be helped by understanding the symptoms caused by bacterial fruit blotch in accessions belonging to different species and varieties of *Citrullus*. Most of the studies evaluated watermelon and melon (*Cucumis melo* L.) resistance to bacterial fruit blotch based on foliar symptoms in the field and greenhouse (Rane and Latin, 1992; Hopkins and Thompson, 2002; Bahar et al., 2009; Wechter et al., 2011; Carvalho et al., 2012). Disease symptoms caused by bacterial fruit blotch have been described (Mullin and

Schenck, 1963; Webb and Goth, 1965), and they became the standard criteria for field identification. However, reports that described the bacterial fruit blotch foliar symptoms were based on only a few cultivars, and may not be as useful for accessions of related species and varieties, for example, *C. colocynthis, C. lanatus* var. *citroides, C. rehmii,* and *Praecitrullus fistulosus*, which together with *C. lanatus* constitute the USDA watermelon germplasm collection.

Observations of watermelon accessions that were part of a screening study of the USDA watermelon germplasm collection in 2011 to 2013 revealed a diversity of symptoms caused by bacterial fruit blotch. This observation is in agreement with the previous studies on *Pseudomonas syringae*, where *P. syringae* collectively infects hundreds of diverse plant species and causes disease symptoms ranging from leaf spots to stem cankers (Melotto et al., 2006). It is not clear why there are such differences, but plant leaves provide an important niche for microbial inhabitation (Melotto et al., 2006).

Trichomes and stomates are two of most important structures in the phyllosphere of terrestrial plants and are important for bacterial colonization of *P. syringae* and *Xanthomonads* (Beattie and Lindow, 1999). Bacteria also colonize other plant parts, living on the cuticle surface, beneath the cuticle, and near hydathodes. Disease is correlated with internal and external bacterial population (Allington and Chamberlain, 1949; Beattie and Lindow, 1999). This has been reported for *P. syringae* pvs. *coranafaciens*, *glycinea, papulans, syringae, and tomato, X. campestris* pvs. *phaseoli* and *undulosa*; *X. translucens* pv. *translucens;* and *E. amylovora* (Hirano and Upper, 1990; Mew and Kennedy, 1982; Bedford et al., 1988; Hirano and Upper, 1993; Lindemann et al., 1984; Rouse et al., 1985; Smitley and McCarter, 1982; Weller and Saettler, 1980; Stromberg et al., 1999; Thomson et al., 1976). Also, there is a correlation between external and internal bacterial population (Beattie and Lindow, 1999). Since trichomes and stomates are important for disease colonization, it is important to study their relationship to foliar symptoms of susceptible watermelon accessions.

Besides being a common site for bacterial colonization, stomates play an important role in defending against bacterial invasion as part of the common defense systems of plants (Melotto et al., 2006). Bacteria enter leaf tissue through natural openings in the leaf surface because they lack the ability that fungi have to produce cuticle-and cellwall-degrading enzymes or mechanically penetrate the plant epidermis. The hydathodes, nectarthodes, lenticels, and stomates represent the most important routes for the entry of foliar bacterial pathogens. In studies of the stomatal defense mechanism, size of the aperture had a significant effect (Melotto et al., 2006). The amount of time the stomates are open after bacterial inoculation is related to disease incidence. In pathogen-associated molecular pattern (PAMP), the induction of stomatal closure effectively blocks the passage of certain bacteria. However, if the bacteria have the *cor* gene, then they will overcome this restriction and cause stomates to open. In field screening for disease resistance, environmental stress and other pathogens may affect foliar symptoms. It may be useful to supplement foliar symptom ratings with measurement of the width of the stomatal aperture to help identify resistance.

The objectives of this study were to understand the impact of the density of trichome and stomates on symptoms caused by bacterial fruit blotch and to determine how leaf surface structure influenced plant response to bacterial fruit blotch among 4 four *Citrullus* species and varieties from the USDA watermelon germplasm collection.

2. MATERIALS AND METHODS

2.1 Plant Materials

Watermelon leaf tissues were sampled at 7 days after inoculation at the Horticultural Crops Research Station in Clinton, NC. Watermelon accessions were treated in the field with a foliar application of bacteria. The suspension consisted of a mix of *Acidovarax avenae* subsp. *citrulli* group II strains AAC 00-1 and AAC 94-21at 10^6 cfu/ml. Plants were sampled using the fourth fully expanded leaf. Accessions studied were PI 482246 (*Citrullus lanatus*), PI 381746 (*Praecitrullus fistulosus*), PI 368527 (*C. lanatus*), PI 482331(*C. lanatus var. citroides*), and Grif 16135 (*C. lanatus var. citroides* (formerly classified as *C. rehmii*)). Two leaf samples were collected from PI 368527, one infected with bacterial fruit blotch, and the other symptom free. No disease symptoms were observed on leaf samples from PI 482246 and PI 4822331 (they were identified to be resistant). Severe disease symptoms were found on leaf samples from Grif 16135, PI 368527 and PI 381746. Additional uninfected PI 368527 was included. All samples were handled carefully to avoid damage to leaf surface structure.

Selected areas along the veins of watermelon leaves were cut with a razor blade into $3mm^2$ pieces and fixed in cold 3% glutaraldehyde in 0.05M potassium phosphate buffer (comprised of mixture of monobasic and dibasic potassium phosphate stock) at pH 7.0 for 48 h at 4°C for fixation. They were then rinsed in three 1-hour changes of cold buffer as above, followed by a graded dehydration series of 1-hour changes in cold 30% and 50% EtOH, then held overnight in 70% EtOH at 4 °C. Dehydration was completed with 1-hour changes of cold 95% and 100% EtOH at 4°C warming to room temperature in the 100% EtOH. Two additional 1-hour changes of room temperature 100% EtOH completed the dehydration series. The samples were then dried in liquid CO_2 (Samdri-795, Tousimis Research Corp., Rockville MD) for 15 minutes at the critical point. The samples were then mounted on stubs with double stick tape. All samples were sputter coated with 50Å of Au/Pd (Hummer 6.2, Anatech U.S.A., Hayward CA) and then held in a vacuum desiccator until viewed using a JEOL JSM 5900LV scanning electron microscope (JEOL U.S.A., Peabody MA) at 15 kV.

2.2 Data Collection

For each of the sampled accessions, the upper and lower surfaces of each leaf were examined for number of trichomes, number of stomata, the ratio of open to closed stomata, and the width of the stomatal aperture. The ImageJ computer application (National Institutes of Health, Bethesda, Maryland) was used to measure stomatal aperture.

3. RESULTS

3.1 Trichome density

Regardless of bacterial infection on leaf surface and cultigen, the lower surface had higher trichome density than the upper surface (Fig. 3.1) in all the PI accessions. The lower surface of the leaves of PI 381746 was 10.5 times higher in trichome density than the upper surface, followed by Grif 16135, which was 7 times higher. Of all the leaf tissues, PI 482246 had higher trichome density on both the upper and lower surface than the others, with 390/mm^2 on the upper surface and 986/mm^2 on the lower surface. On PI 368527, the upper and lower surface trichome densities were different on the diseased leaf sample and uninfected leaf samples. However, the ratio of lower to upper surface trichome density was similar (1.9 and 2.4, respectively). The two resistant cultigens PI 482246 and PI 482231, which were uninfected or only lightly infected by bacterial fruit blotch, had a ratio of 2.5 and 2.6, respectively.

3.2 Stomata Density and Stomatal Aperture

Regardless of bacterial infection on leaf surface and cultigen, the lower surface had higher stomata density than the upper surface (Fig. 3.2). The lower surface stomata density was 1.5 times higher than the stomata density on the upper surface.

Stomatal aperture size on upper surface from infected PI 368527 and Grif 16135 was larger than for the other samples. For the same cultigen, infection enlarged the size of stomate apertures on PI 368527 (Fig. 3.3). There was a negative correlation between stomatal density and stomatal aperture.

All samples had more open stomates than closed stomates on both upper and lower leaf surface except Grif 16135. In Grif 16135, the lower leaf surface had 12 closed stomates and 6 open stomates. Leaf samples that were collected with heavy disease symptoms had all the stomates open (Fig.3.4).

3.4 Bacterial Distribution

Seven days after inoculation with bacterial fruit blotch strains AAC 00-1 and AAC 94-21at 10^6 cfu/ml, the bacteria were randomly dispersed over the leaf surface around stomates and trichomes (Figs. 4.4b and c) and masses of bacteria filled some of the stomates (Fig. 4.4d).

4. DISCUSSION

Generally, the lower surface had higher trichome density than the upper surface. All accessions were similar for trichome relationships: PI 482246 (*C.s. lanatus*), PI 381746 (*Praecitrullus fistulosus*), PI 368527 (*C. lanatus*), PI 482331(*C. lanatus var. citroides*), and Grif 16135 (*C. lanatus var. citroides* (formerly classified as *C. rehmii*)). As reported before, trichomes are an important location for bacterial colonization. When plants were susceptible to bacterial fruit blotch like PI 368527, the trichome density on infected leaf samples was greatly reduced on both upper and lower leaf surfaces than that on uninfected or lightly infected leaf samples. This reduced number of trichomes was an indicator that trichomes were an important location for bacterial colonization. Therefore, the distribution pattern and number of trichomes may affect bacterial fruit blotch symptoms among *Citrullus* species and varieties. However, information obtained from trichomes alone were not sufficient to determine bacterial fruit blotch resistance for the accessions evaluated in this study. Even though uninfected PI 482246 and PI 368527 had similar trichome density, PI 482246 was resistant and PI 368527 was susceptible after inoculation with bacterial fruit blotch.

Similarly, stomates were also an important location for bacterial colonization and one of the most important natural openings in the leaf surface for bacterial entry into plant epidermis (Beattie and Lindow, 1999; Melotto et al., 2006). Stomatal density on infected leaves was lower than on uninfected leaf samples, most likely due to the enlarged stomatal aperture. There was a negative correlation between the number of stomates and the size the stomatal aperture on PI 368527. The widely open stomates provided access for pathogen penetration into watermelon leaf tissues. In the scanning electron microscope photographs, large numbers of bacteria were detected on infected PI 368527 and PI 381746. Differences in stomatal density and size of stomatal aperture between plants provided evidence that stomates were an important natural opening for *A. avidovarax avenae* subsp, *citrulli* to penetrate the leaf tissue. The difference in stomatal density on uninfected leaf tissue among species might also contribute to different disease symptoms. When PI accessions are susceptible, the denser the stomates, larger lesions can be expected.

Stomates also play an important role in defending against invasion as part of the natural resistance of plants (Melotto et al., 2008). Large stomatal apertures were found on heavily infected PI 368528 leaf tissue. Previous studies reported that the opening and closing of stomates after bacterial inoculation over time are indicators of interaction between bacteria and plants (Melotto et al., 2006). Both plant pathogen *Pst* DC3000 and human pathogenic bacteria *Escherichia coli* O157:H7 induced stomates to close within 2 h of inoculation on *Arabidopsis*, and only *Pst* DC3000 induced the stomates to reopen after 3 h. The initial closure was initiated by guard cells due to PAMP, a conserved immunity mechanism. This stomate reopening phenomenon was caused by a mechanism that could counter PAMP-induced stomatal closure. In this study, we found almost all leaf tissues taken from susceptible PI accessions (PI 381746, PI 368527, and Grif 16135) had no closed stomates, while the resistant PI accession (PI 482246) had both open and closed stomates. Also, aperture size of stomates on infected leaf tissue that were forced open was larger than naturally open stomates on uninfected tissue for PI 368527. Taken together, these results showed that bacterial fruit blotch strains AAC0-01 and AAC 94-21 have virulence factors to suppress stomatal PAMP defense and resistant PI accessions have mechanisms to counter the virulence factors in the bacterial pathogen. Therefore, the change in size of stomate aperture and number of open and closed stomates before and after inoculation with *A. avenae* subsp. *citrulli* can be used as resistance traits.

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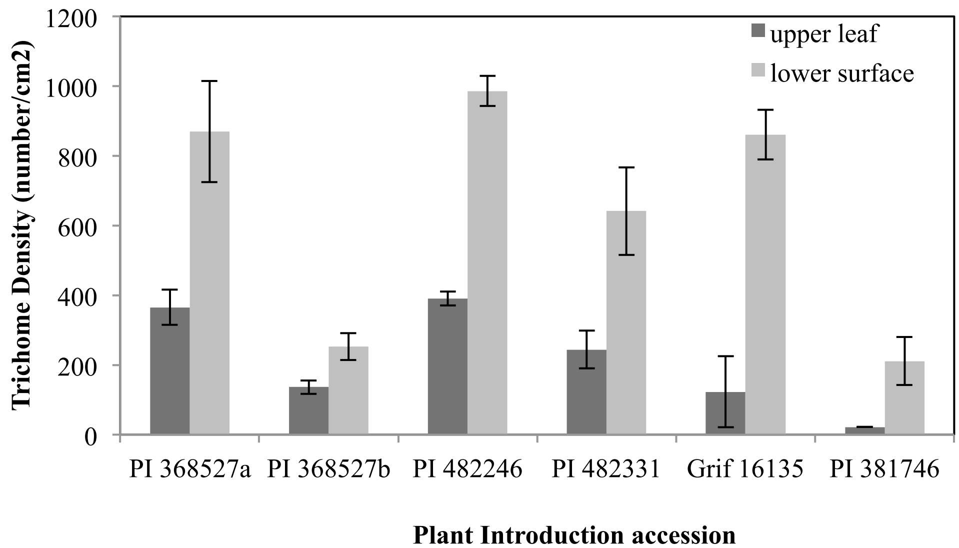

Fig. 3.1. Trichome density (number/cm^2) on selected plant introduction accessions 7 days after inoculation with *Acidovarax avenae* subsp. *citrulli* at 10^6 cfu/ml with strains AAC 00-1 and AAC 94-21. PI 368527a (*Citrullus lanatus*) was lightly or uninfected by *A. avenae* subsp. *citrulli*; PI 368527b (*C. lanatus*) was heavily infected with *A. avenae* subsp. *citrulli*; PI 482246 (*C. lanatus*) and PI 482331 (*C. lanatus* var. *citroides*) were free of disease symptoms caused by *A. avenae* subsp. *citrulli*; Grif 16135 (*C. lanatus* var. *citroides*, was *C. rehmii* before June 2011) and PI 381746 (*Praecitrullus fistulosus*) was heavily infected by *A. avenae* subsp. *citrulli*.

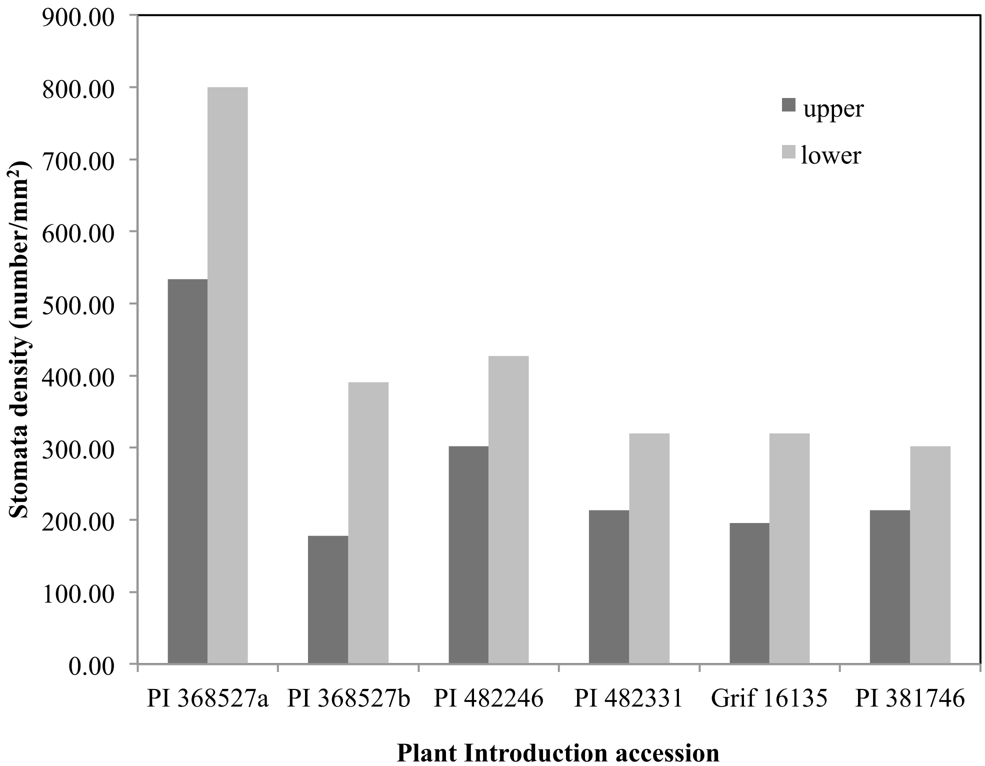

Fig. 3.2. Stomate density (number/cm^2) on selected plant introduction accessions 7 days after inoculation with *Acidovarax avenae* subsp. *citrulli* at 10^6 cfu/ml with strains AAC 00-1 and AAC 94-21. PI 368527a (*Citrullus lanatus*) was lightly or uninfected by *A. avenae* subsp. *citrulli*; PI 368527b (*C. lanatus*) was heavily infected with *A. avenae* subsp. *citrulli*; PI 482246 (*C. lanatus*) and PI 482331 (*C. lanatus* var. *citroides*) were free of disease symptoms caused by *A. avenae* subsp. *citrulli*; Grif 16135 (*C. lanatus* var. *citroides*, was *C. rehmii* before June 2011) and PI 381746 (*Praecitrullus fistulosus*) was heavily infected by *A. avenae* subsp. *citrulli.*

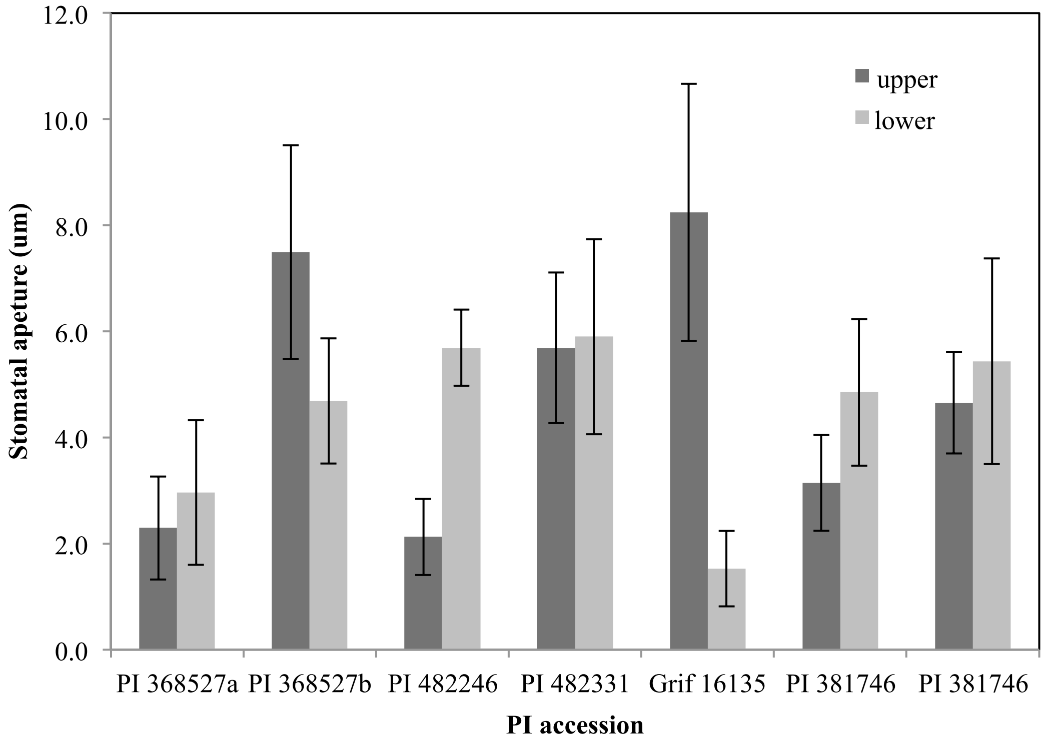

Fig. 3.3. Stomatal aperture on selected plant introduction accessions 7 days after inoculation with *Acidovarax avenae* subsp. *citrulli* at 10^6 cfu/ml with strains AAC 00-1 and AAC 94-21. PI 368527a (*Citrullus lanatus*) was lightly or uninfected by *A. avenae* subsp. *citrulli*; PI 368527b (*C. lanatus*) was heavily infected with *A. avenae* subsp. *citrulli*; PI 482246 (*C. lanatus*) and PI 482331 (*C. lanatus* var. *citroides*) were free of disease symptoms caused by *A. avenae* subsp. *citrulli*; Grif 16135 (*C. lanatus* var. *citroides*, was *C. rehmii* before June 2011) and PI 381746 (*Praecitrullus fistulosus*) was heavily infected by *A. avenae* subsp. *citrulli.*

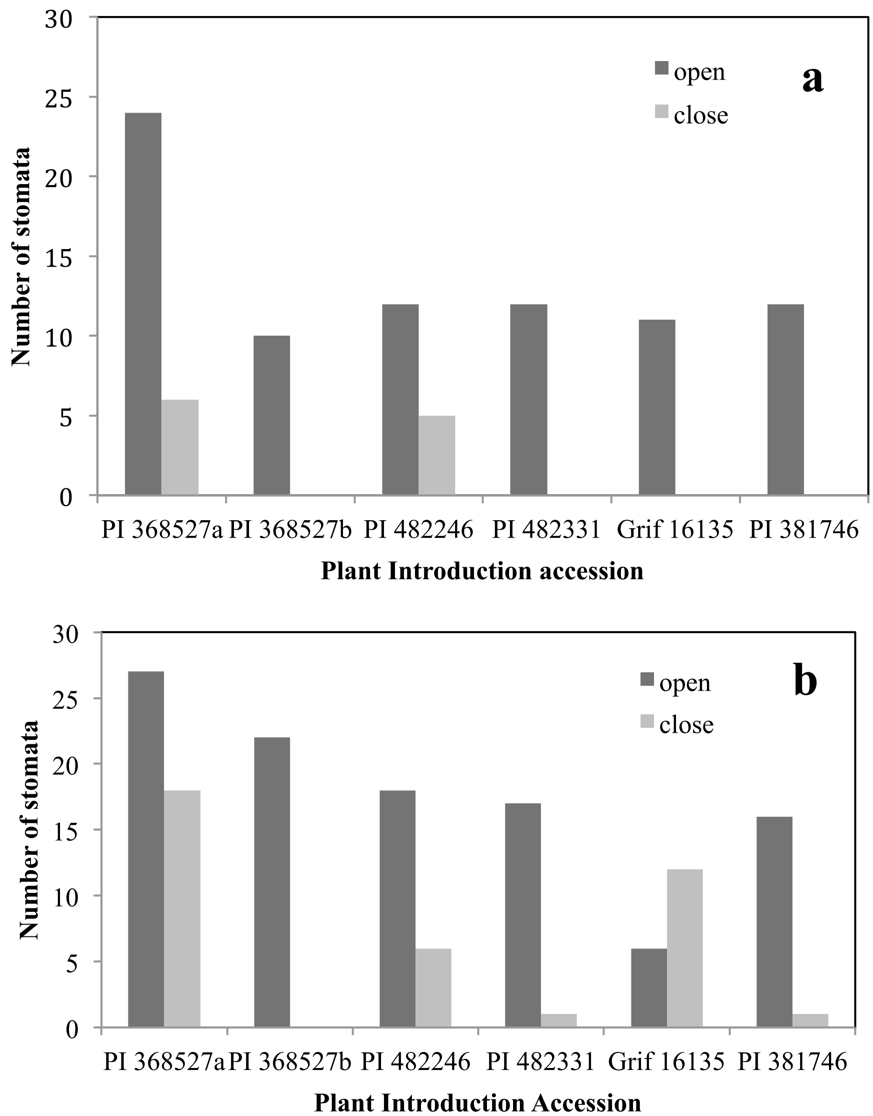

Fig. 3.4. Number of open and closed stomates on the upper leaf surface (a) and lower leaf surface (b) of selected plant introduction accessions 7 days after inoculation with *Acidovarax avenae* subsp. *citrulli* at 10^6 cfu/ml with strains AAC 00-1 and AAC 94-21. PI 368527a (*Citrullus lanatus*) was lightly or uninfected by *A. avenae* subsp. *citrulli*; PI 368527b (*C. lanatus*) was heavily infected with *A. avenae* subsp. *citrulli*; PI 482246 (*C. lanatus*) and PI 482331 (*C. lanatus* var. *citroides*) were free of disease symptoms caused by *A. avenae* subsp. *citrulli*; Grif 16135 (*C. lanatus* var. *citroides*, was *C. rehmii* before June 2011) and PI 381746 (*Praecitrullus fistulosus*) was heavily infected by *A. avenae* subsp. *citrulli.*

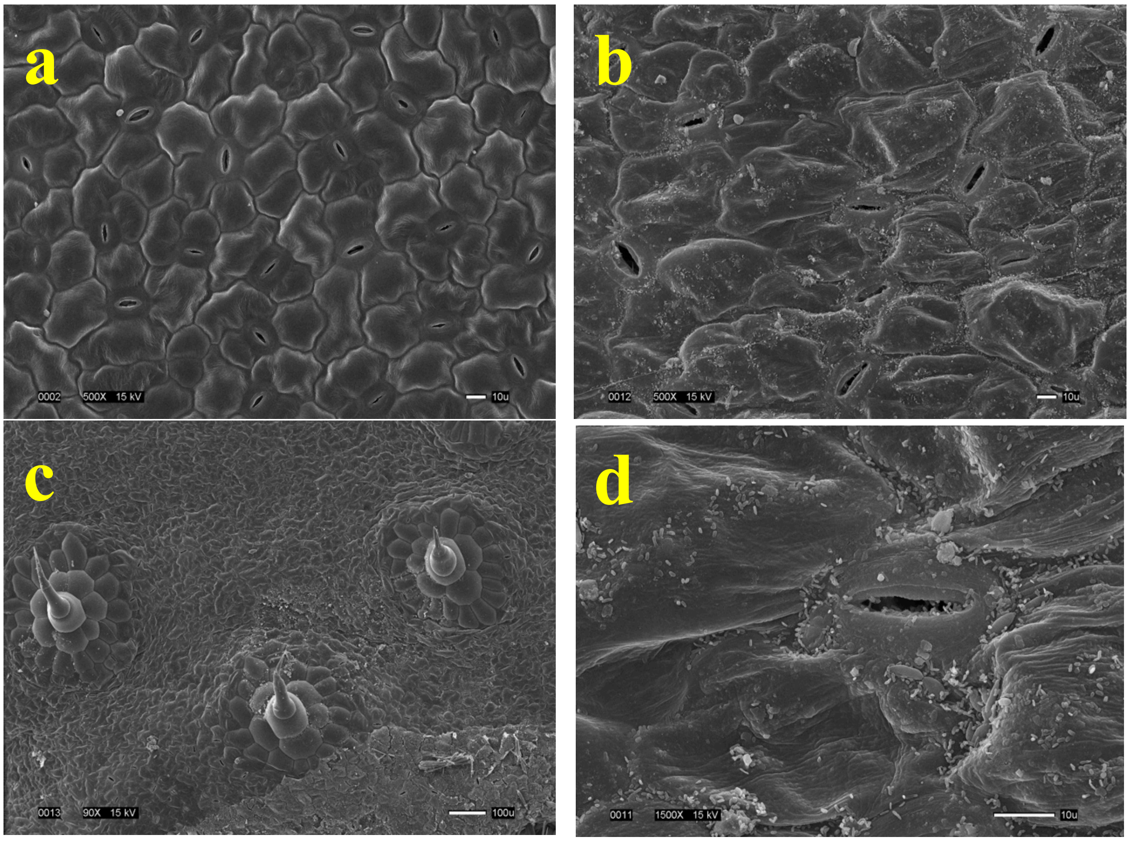

Fig. 3.5. Bacterial distribution on leaf surface 7 days after inoculation of bacterial fruit blotch (*Acidovarax avanae* subsp. *citrulli*) strain types AAC 00-1 and AAC 94-21 at 10^6 cfu/ml on PI 368527. a) clean leaf surface free of bacteria on uninfected leaf sample; b) bacteria colonies all around stomata and enlarged stomata aperture; c) bacteria colonies all around trichomes; d) bacteria entered leaf tissue via stomata. All photographs were taken under JEOL JSM 5900LV scanning electron microscope (JEOL U.S.A., Peabody MA) at 15 kV.

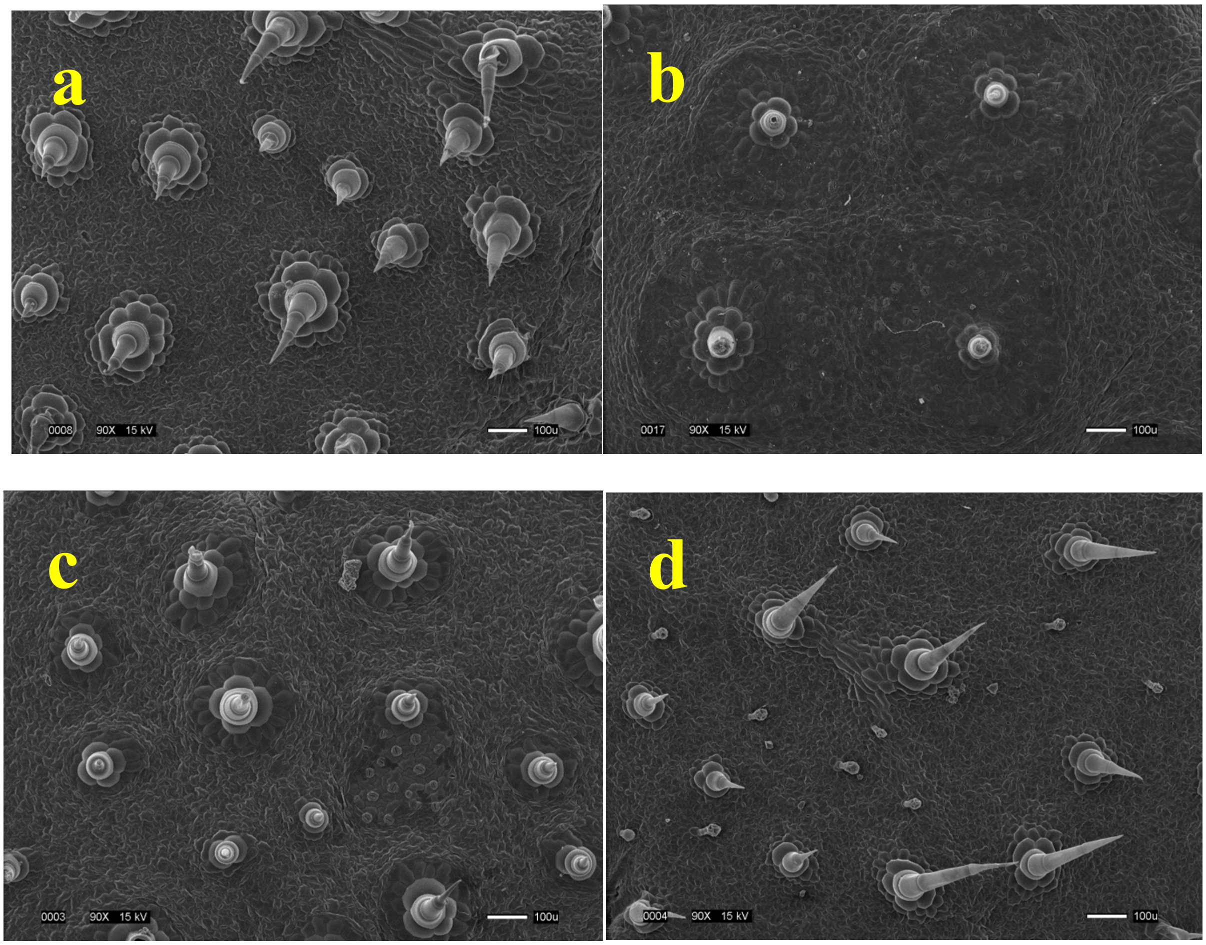

Fig. 3.6.Trichomes on lower leaf surface of selected plant introduction accessions 7 days after inoculation with *Acidovarax avenae* subsp. *citrulli* at 10^6 cfu/ml with strains AAC 00-1 and AAC 94-21. a) Grif 16135 (*C. lanatus* var. *citroides*, was *C. rehmii* before June 2011); b) PI 381746 (*Praecitrullus fistulosus*) was heavily infected by *A. avenae* subsp. *citrulli*; c) PI 482331 (*C. lanatus* var. *citroides*) were free of disease symptoms; d) PI 368527 (*Citrullus lanatus*) was lightly or uninfected by *A. avenae* subsp. *citrulli*.

APPENDICES

Appendix 1

Complete list of the watermelon germplasm collection ranked based on the 3rd rating of bacterial fruit blotch screening over 2011 to 2013 (with the seed source).

Rank	Cultigen	Seed source	Ave. †	Max‡	SD§	No. ¶	1st #	2nd	3rd
1	PI 278010	Turkey	2.3	3.0	.	1	3.0	3.0	1.0
2	PI 494530	Nigeria	2.3	.	.	0	2.5	2.7	1.7
3	PI 542113	Botswana	4.7	6.0	.	1	6.0	5.0	3.0
4	PI 542117	Botswana	5.3	7.0	.	1	6.0	7.0	3.0
5	PI 549160	Chad	2.3	4.0	.	2	1.0	3.0	3.0
6	PI 556995	United States	3.0	5.0	.	2	2.5	3.5	3.0
7	PI 482246	Zimbabwe	2.4	4.0	0.0	3	1.7	2.7	3.0
8	PI 482273	Zimbabwe	2.5	7.0	0.0	4	1.8	2.7	3.0
9	PI 482322	Zimbabwe	2.8	6.0	0.7	5	2.3	3.2	3.0
10	PI 596666	South Africa	2.8	7.0	1.4	5	2.2	3.2	3.2
11	PI 532670	Zimbabwe	2.9	6.0	0.0	3	2.3	3.0	3.3
12	PI 271770	South Africa	3.2	6.0	0.0	4	2.7	3.7	3.3
13	PI 482300	Zimbabwe	3.5	7.0	0.0	5	3.0	4.2	3.3
14	Jubilee	United States	2.0	4.0	0.7	2	1.5	1.0	3.5
15	PI 490377	Mali	2.7	4.0	.	2	1.0	3.5	3.5
16	PI 596667	South Africa	3.7	7.0	.	2	2.5	5.0	3.5
17	Grif 12335	China	3.3	5.0	.	3	3.0	3.5	3.5
18	PI 482277	Zimbabwe	2.9	6.0	0.7	5	2.0	3.3	3.5
19	PI 482331	Zimbabwe	3.6	6.0	0.7	5	3.0	4.2	3.5
20	PI 596669	South Africa	3.7	7.0	3.5	5	3.5	4.2	3.5
21	PI 482309	Zimbabwe	3.3	6.0	1.4	6	2.8	3.5	3.5
22	PI 482324	Zimbabwe	3.6	5.0	0.7	6	3.5	3.7	3.5
23	PI 482326	Zimbabwe	4.0	7.0	0.0	6	4.0	4.5	3.5
24	PI 596665	South Africa	3.2	9.0	0.0	6	2.2	3.8	3.5
25	PI 500331	Zambia	2.8	6.0	0.7	5	1.3	3.5	3.7
26	PI 596668	South Africa	3.3	6.0	0.7	5	2.5	3.8	3.7
27	PI 485583	Botswana	3.6	6.0	1.4	6	3.0	4.2	3.7
28	PI 560006	Nigeria	2.8	7.0	3.5	6	1.8	2.8	3.7
29	PI 296337	South Africa	2.7	5.0	0.0	5	1.7	2.5	3.8
30	PI 482274	Zimbabwe	3.1	6.0	0.7	5	2.0	3.5	3.8
31	PI 482284	Zimbabwe	3.7	6.0	2.1	5	3.0	4.2	3.8
32	PI 500323	Zambia	3.8	7.0	0.0	5	3.2	4.5	3.8
33	PI 500354	Zambia	3.3	6.0	0.7	5	2.7	3.3	3.8
34	PI 532664	Zimbabwe	3.3	7.0	0.0	5	2.3	3.7	3.8
35	PI 482252	Zimbabwe	3.7	6.0	1.4	6	3.3	3.8	3.8

Appendix 1 continued

36	PI 482318	Zimbabwe	3.0	7.0	0.0	6	1.5	3.7	3.8
37	PI 482333	Zimbabwe	3.5	7.0	1.4	6	2.8	3.8	3.8
38	PI 500327	Zambia	3.6	7.0	2.1	6	3.2	3.8	3.8
39	PI 595201	United States	3.2	6.0	0.0	6	2.7	3.0	3.8
40	PI 167219	Turkey	4.3	5.0	.	1	4.0	5.0	4.0
41	PI 482279	Zimbabwe	3.7	5.0	.	1	2.0	5.0	4.0
42	PI 505604	Zambia	2.3	4.0	.	1	1.0	2.0	4.0
43	PI 459074	Botswana	3.3	5.0	.	2	2.5	3.5	4.0
44	PI 307608	Nigeria	4.3	6.0	0.0	3	4.0	5.0	4.0
45	PI 537277	Pakistan	3.9	9.0	0.0	3	3.3	4.5	4.0
46	PI 482265	Zimbabwe	4.0	7.0	0.7	5	3.3	4.7	4.0
47	PI 482303	Zimbabwe	3.4	8.0	0.7	5	2.5	3.8	4.0
48	PI 482311	Zimbabwe	3.3	7.0	1.4	5	2.0	3.8	4.0
49	PI 482319	Zimbabwe	3.8	7.0	2.1	5	2.8	4.5	4.0
50	PI 482361	Zimbabwe	3.6	7.0	0.7	5	2.5	4.3	4.0
51	PI 500334	Zambia	4.0	7.0	1.4	6	3.7	4.3	4.0
52	PI 357739	Yugoslavia	4.1	7.0	0.0	4	3.7	4.5	4.2
53	PI 244019	South Africa	3.8	7.0	1.4	5	3.3	4.0	4.2
54	PI 482316	Zimbabwe	3.8	6.0	0.7	5	3.5	3.7	4.2
55	PI 500319	Zambia	4.2	7.0	1.4	5	3.7	4.7	4.2
56	PI 532738	Zaire	3.6	7.0	0.0	5	2.8	3.7	4.2
57	PI 534593	Syria	4.2	9.0	0.0	5	4.2	4.3	4.2
58	PI 595203	United States	2.8	6.0	0.7	5	1.3	3.0	4.2
59	PI 596696	South Africa	3.3	6.0	1.4	5	2.0	3.8	4.2
60	PI 296342	South Africa	2.8	5.0	0.7	6	1.7	2.5	4.2
61	PI 482307	Zimbabwe	3.7	7.0	0.0	6	2.7	4.3	4.2
62	PI 482367	Zimbabwe	2.9	6.0	0.0	6	1.3	3.3	4.2
63	PI 500308	Zambia	3.8	7.0	0.7	6	3.2	4.0	4.2
64	PI 500328	Zambia	3.3	8.0	0.0	6	2.0	3.7	4.2
65	PI 500332	Zambia	3.3	8.0	1.4	6	2.2	3.5	4.2
66	PI 532732	Zimbabwe	3.9	7.0	0.7	6	3.5	4.0	4.2
67	PI 596662	South Africa	3.7	7.0	0.7	6	2.7	4.3	4.2
68	PI 482247	Zimbabwe	4.3	7.0	.	4	3.5	5.3	4.3
69	AU-Producer	United States	4.3	6.0	0.0	2	4.0	4.3	4.3
70	PI 357701	Yugoslavia	4.0	9.0	0.0	3	2.7	5.0	4.3
71	PI 299379	South Africa	3.4	6.0	0.0	4	2.2	3.7	4.3
72	PI 482315	Zimbabwe	3.9	7.0	0.0	4	3.2	4.2	4.3
73	PI 482336	Zimbabwe	3.8	7.0	0.0	4	2.5	4.5	4.3
74	PI 600790	United States	3.6	9.0	0.0	4	2.5	4.0	4.3

Appendix1 continued

75	PI 271779	South Africa	3.4	5.0	0.7	5	3.2	2.8	4.3
76	PI 482291	Zimbabwe	3.7	7.0	0.7	5	2.7	4.0	4.3
77	PI 596656	South Africa	3.5	6.0	0.0	5	2.3	3.8	4.3
78	PI 596659	South Africa	3.4	7.0	1.4	5	2.3	3.7	4.3
79	Grif 15897	Russia	3.4	8.0	0.7	6	2.0	3.8	4.3
80	PI 248774	Namibia	3.4	7.0	0.7	6	2.7	3.2	4.3
81	PI 255137	South Africa	4.0	9.0	2.1	6	3.7	4.0	4.3
82	PI 482335	Zimbabwe	3.9	7.0	0.7	6	3.7	3.8	4.3
83	PI 482355	Zimbabwe	3.2	7.0	1.4	6	1.3	4.0	4.3
84	PI 532666	Zimbabwe	3.8	6.0	0.0	6	3.2	4.0	4.3
85	PI 596653	South Africa	3.5	7.0	0.7	6	3.2	3.0	4.3
86	PI 596676	South Africa	4.1	7.0	0.7	6	3.7	4.2	4.3
87	PI 295843	South Africa	3.1	7.0	0.7	3	1.7	3.3	4.3
88	PI 482283	Zimbabwe	3.7	5.0	0.7	3	3.0	3.9	4.4
89	PI 204689	Turkey	4.0	5.0	.	2	3.0	4.5	4.5
90	PI 490384	Mali	3.0	5.0	.	2	2.0	2.5	4.5
91	PI 596692	South Africa	4.5	6.0	.	2	4.0	5.0	4.5
92	PI 177322	Turkey	4.3	8.0	2.1	4	4.0	4.3	4.5
93	PI 229749	Iran	3.8	8.0	2.1	4	2.7	4.2	4.5
94	PI 482282	Zimbabwe	4.2	6.0	0.0	4	3.3	4.7	4.5
95	PI 485580	Botswana	3.7	5.0	0.0	4	2.7	3.8	4.5
96	PI 560901	China	2.9	9.0	0.0	4	1.5	2.8	4.5
97	PI 211852	Iran	3.8	9.0	1.4	5	3.0	4.0	4.5
98	PI 244017	South Africa	3.2	7.0	2.1	5	1.8	3.3	4.5
99	PI 482288	Zimbabwe	3.7	6.0	1.4	5	2.8	3.8	4.5
100	PI 482296	Zimbabwe	3.9	9.0	0.0	5	3.5	3.7	4.5
101	PI 500335	Zambia	3.9	7.0	0.7	5	2.7	4.5	4.5
102	PI 532667	Zimbabwe	3.4	7.0	0.7	5	1.8	4.0	4.5
103	PI 600903	United States	3.8	7.0	2.8	5	2.8	4.0	4.5
104	Grif 15896	Russia	3.7	8.0	1.4	6	2.5	4.2	4.5
105	PI 244018	South Africa	3.9	7.0	2.1	6	3.3	4.0	4.5
106	PI 482293	Zimbabwe	3.7	7.0	0.0	6	2.7	3.8	4.5
107	PI 482308	Zimbabwe	4.1	7.0	0.7	6	3.3	4.3	4.5
108	PI 500306	Zambia	4.1	8.0	2.1	6	3.3	4.3	4.5
109	PI 526231	Zimbabwe	3.6	7.0	0.7	6	2.0	4.2	4.5
110	PI 532624	Zimbabwe	3.7	7.0	2.8	6	2.8	3.8	4.5
111	PI 560000	Nigeria	3.2	6.0	0.0	6	1.7	3.5	4.5
112	PI 248178	Zaire	3.6	7.0	0.0	3	2.7	3.6	4.6
113	PI 482261	Zimbabwe	3.4	7.0	2.8	4	1.5	4.0	4.7

Appendix1 continued

114	PI 254622	Sudan	3.6	9.0	0.0	5	1.7	4.3	4.7
115	PI 255136	South Africa	4.0	7.0	2.1	5	3.2	4.2	4.7
116	PI 255139	South Africa	3.9	7.0	2.1	5	3.7	3.3	4.7
117	PI 482278	Zimbabwe	3.4	8.0	0.7	5	1.3	4.2	4.7
118	PI 490381	Mali	3.9	8.0	2.1	5	3.2	4.0	4.7
119	PI 500301	Zambia	3.3	7.0	0.7	5	1.8	3.5	4.7
120	PI 532668	Zimbabwe	4.2	7.0	1.4	5	3.5	4.5	4.7
121	PI 178874	Turkey	3.8	7.0	0.7	6	2.7	4.0	4.7
122	PI 186490	Nigeria	3.6	9.0	1.4	6	2.3	3.8	4.7
123	PI 249010	Nigeria	4.0	8.0	1.4	6	3.2	4.2	4.7
124	PI 270564	South Africa	4.1	7.0	0.7	6	3.2	4.3	4.7
125	PI 271775	South Africa	3.7	7.0	1.4	6	2.7	3.7	4.7
126	PI 296343	South Africa	3.1	5.0	0.0	6	1.7	3.0	4.7
127	PI 482257	Zimbabwe	4.1	6.0	1.4	6	4.0	3.7	4.7
128	PI 482272	Zimbabwe	3.2	7.0	2.1	6	1.8	3.0	4.7
129	PI 482286	Zimbabwe	3.7	7.0	1.4	6	2.3	4.0	4.7
130	PI 482312	Zimbabwe	3.9	7.0	2.1	6	3.3	3.7	4.7
131	PI 482342	Zimbabwe	3.4	7.0	1.4	6	2.0	3.5	4.7
132	PI 485581	Botswana	4.5	7.0	0.0	6	3.8	5.0	4.7
133	PI 494531	Nigeria	3.5	7.0	0.7	6	1.8	4.0	4.7
134	PI 500314	Zambia	3.6	7.0	1.4	6	2.0	4.2	4.7
135	PI 500320	Zambia	3.4	8.0	2.8	6	2.3	3.3	4.7
136	PI 512854	Spain	3.8	7.0	0.7	6	2.8	3.8	4.7
137	PI 481871	Sudan	4.1	7.0	.	3	2.8	4.8	4.8
138	PI 379236	Yugoslavia	4.4	9.0	.	5	3.8	4.8	4.8
139	Honey Red	United States	3.7	9.0	0.0	5	2.7	4.0	4.8
140	PI 500316	Zambia	3.7	6.0	0.7	4	2.7	3.5	4.8
141	PI 532669	Zimbabwe	4.6	7.0	0.0	4	3.8	5.0	4.8
142	PI 169273	Turkey	3.8	9.0	0.0	5	2.8	3.8	4.8
143	PI 169283	Turkey	4.3	7.0	0.7	5	4.3	3.7	4.8
144	PI 189225	Zaire	4.2	7.0	1.4	5	3.3	4.3	4.8
145	PI 345543	Ukraine	4.1	7.0	0.7	5	2.8	4.7	4.8
146	PI 368505	Yugoslavia	4.1	9.0	0.0	5	3.0	4.3	4.8
147	PI 379243	Yugoslavia	3.8	7.0	0.7	5	2.5	4.0	4.8
148	PI 482267	Zimbabwe	4.0	7.0	0.7	5	3.0	4.2	4.8
149	PI 482269	Zimbabwe	4.5	7.0	0.0	5	3.5	5.2	4.8
150	PI 482290	Zimbabwe	4.3	7.0	2.8	5	3.7	4.5	4.8
151	PI 500321	Zambia	3.3	7.0	2.1	5	2.2	3.0	4.8
152	PI 532733	Zimbabwe	3.6	8.0	2.1	5	2.2	3.7	4.8

Appendix1 continued

153	PI 560011	Nigeria	3.6	7.0	0.0	5	2.3	3.7	4.8
154	PI 233556	Japan	3.7	7.0	0.7	6	2.8	3.5	4.8
155	PI 271769	South Africa	3.8	7.0	0.7	6	2.8	3.8	4.8
156	PI 271773	South Africa	4.1	6.0	1.4	6	3.0	4.3	4.8
157	PI 271774	South Africa	3.7	6.0	0.7	6	2.3	3.8	4.8
158	PI 295842	South Africa	3.8	7.0	0.7	6	2.8	3.7	4.8
159	PI 299378	South Africa	4.4	9.0	2.8	6	3.7	4.7	4.8
160	PI 357695	Yugoslavia	4.4	8.0	0.0	6	4.3	4.2	4.8
161	PI 379233	Yugoslavia	4.9	8.0	1.4	6	4.5	5.3	4.8
162	PI 458739	Paraguay	3.7	7.0	0.0	6	3.0	3.2	4.8
163	PI 482328	Zimbabwe	3.8	7.0	1.4	6	2.8	3.7	4.8
164	PI 482372	Zimbabwe	3.7	8.0	2.8	6	2.3	4.0	4.8
165	PI 482373	Zimbabwe	3.9	7.0	0.7	6	2.7	4.2	4.8
166	PI 500303	Zambia	3.4	7.0	0.0	6	2.0	3.5	4.8
167	PI 549163	Chad	3.9	7.0	1.4	6	3.2	3.8	4.8
168	PI 560008	Nigeria	3.8	7.0	0.7	6	2.5	4.0	4.8
169	PI 560023	Nigeria	2.9	7.0	0.7	6	1.0	3.0	4.8
170	PI 595202	United States	3.4	7.0	1.4	6	2.2	3.3	4.8
171	PI 596671	South Africa	3.9	7.0	2.1	6	2.2	4.7	4.8
172	PI 606135	Russia	4.3	8.0	2.1	6	4.2	3.8	4.8
173	Florida Favorite	United States	6.3	7.0	.	1	7.0	7.0	5.0
174	Hopi Red Flesh2	United States	4.0	5.0	0.0	1	3.0	4.0	5.0
175	PI 178870	Turkey	4.2	6.0	.	1	4.0	6.0	5.0
176	PI 211011	Afghanistan	4.7	9.0	.	1	5.0	4.0	5.0
177	PI 270141	India	5.3	6.0	.	1	6.0	5.0	5.0
178	PI 273479	Ethiopia	6.3	7.0	.	1	7.0	7.0	5.0
179	PI 288316	India	4.7	5.0	.	1	4.0	5.0	5.0
180	PI 381747	India	6.0	7.0	.	1	7.0	6.0	5.0
181	PI 386016	Iran	6.0	7.0	.	1	7.0	6.0	5.0
182	PI 542121	Botswana	2.7	5.0	.	1	0.0	3.0	5.0
183	Golden Midget2	United States	5.7	6.0	.	2	6.0	6.0	5.0
184	PI 169264	Turkey	4.7	7.0	0.0	2	4.0	5.0	5.0
185	PI 357702	Yugoslavia	3.8	6.0	.	2	2.5	4.0	5.0
186	PI 386014	Iran	3.7	6.0	1.4	2	2.5	3.5	5.0
187	PI 386025	Iran	5.0	7.0	.	2	5.0	5.0	5.0
188	PI 500329	Zambia	3.7	6.0	0.0	2	2.0	4.0	5.0
189	PI 532819	China	2.3	6.0	0.0	2	1.0	1.0	5.0
190	PI 549159	Mauritania	5.0	7.0	0.0	2	4.5	5.5	5.0
191	Super Sweet	United States	4.3	7.0	0.0	2	4.0	4.0	5.0

Appendix1 continued

192	PI 175658	Turkey	5.3	9.0	0.0	3	4.7	6.3	5.0
193	PI 176921	Turkey	5.0	8.0	.	3	3.8	6.3	5.0
194	PI 357663	Yugoslavia	4.1	7.0	0.0	3	3.3	4.0	5.0
195	PI 482276	Zimbabwe	4.6	6.0	.	3	4.3	4.5	5.0
196	PI 482298	Zimbabwe	4.7	6.0	0.0	3	4.0	5.0	5.0
197	GeorgiaRttlsnk1	United States	3.4	6.0	1.4	4	2.3	3.0	5.0
198	PI 295850	South Africa	4.1	6.0	1.4	4	3.7	3.5	5.0
199	PI 296335	South Africa	3.8	5.0	0.0	4	2.7	3.7	5.0
200	PI 357754	Yugoslavia	4.5	7.0	0.0	4	4.0	4.5	5.0
201	PI 525081	Egypt	4.1	7.0	0.0	4	3.0	4.3	5.0
202	TendersweetOF2	United States	4.3	6.0	1.4	4	3.5	4.5	5.0
203	PI 172788	Turkey	4.6	8.0	0.7	5	3.8	5.0	5.0
204	PI 307609	Nigeria	4.4	9.0	2.1	5	4.0	4.2	5.0
205	PI 357713	Yugoslavia	4.2	7.0	0.0	5	3.0	4.5	5.0
206	PI 369220	Soviet Union	4.1	7.0	1.4	5	2.8	4.3	5.0
207	PI 381706	India	4.3	9.0	2.1	5	3.0	4.8	5.0
208	PI 482268	Zimbabwe	4.2	7.0	0.7	5	2.7	4.8	5.0
209	PI 482292	Zimbabwe	4.5	7.0	0.0	5	3.8	4.7	5.0
210	PI 482294	Zimbabwe	3.7	7.0	1.4	5	2.2	3.8	5.0
211	PI 482305	Zimbabwe	4.2	7.0	1.4	5	2.7	4.8	5.0
212	PI 482320	Zimbabwe	3.9	7.0	0.7	5	2.7	4.0	5.0
213	PI 482321	Zimbabwe	3.7	7.0	0.7	5	1.8	4.2	5.0
214	PI 482327	Zimbabwe	4.2	9.0	1.4	5	2.8	4.7	5.0
215	PI 500313	Zambia	3.9	6.0	0.7	5	2.8	4.0	5.0
216	PI 500344	Zambia	3.8	7.0	0.0	5	1.8	4.5	5.0
217	PI 500350	Zambia	3.7	7.0	0.7	5	1.8	4.2	5.0
218	PI 512401	Spain	4.1	8.0	1.4	5	2.5	4.8	5.0
219	PI 596658	South Africa	3.7	7.0	2.1	5	2.2	4.0	5.0
220	PI 271776	South Africa	4.1	7.0	0.7	6	3.3	3.8	5.0
221	PI 277279	India	3.9	9.0	0.0	6	3.5	3.3	5.0
222	PI 379238	Yugoslavia	4.3	7.0	2.8	6	3.3	4.7	5.0
223	PI 482258	Zimbabwe	3.9	7.0	3.5	6	3.0	3.8	5.0
224	PI 482313	Zimbabwe	3.8	7.0	0.0	6	2.3	4.2	5.0
225	PI 482329	Zimbabwe	4.2	7.0	0.0	6	3.0	4.7	5.0
226	PI 482354	Zimbabwe	4.1	8.0	1.4	6	2.8	4.3	5.0
227	PI 482357	Zimbabwe	4.2	8.0	2.8	6	3.0	4.5	5.0
228	PI 482359	Zimbabwe	4.0	7.0	0.0	6	2.8	4.2	5.0
229	PI 500302	Zambia	3.6	7.0	0.7	6	2.2	3.7	5.0
230	PI 500310	Zambia	3.8	7.0	0.7	6	2.7	3.8	5.0

Appendix1 continued

231	PI 500340	Zambia	3.1	6.0	0.7	6	1.3	2.8	5.0
232	PI 500352	Zambia	3.8	7.0	1.4	6	2.8	3.7	5.0
233	PI 505590	Zambia	3.9	7.0	1.4	6	2.8	4.0	5.0
234	PI 534535	Syria	4.1	7.0	2.1	6	2.8	4.5	5.0
235	PI 542114	Botswana	4.4	7.0	1.4	6	4.2	4.2	5.0
236	PI 560020	Nigeria	4.0	8.0	0.7	6	2.7	4.3	5.0
237	PI 583809	United States	4.3	7.0	0.7	6	3.2	4.7	5.0
238	PI 596675	South Africa	4.3	7.0	1.4	6	3.2	4.8	5.0
239	PI 306367	Angola	3.9	6.0	0.0	4	2.5	4.0	5.2
240	PI 438676	Mexico	4.8	7.0	0.0	4	4.0	5.2	5.2
241	PI 169254	Turkey	4.8	7.0	1.4	5	4.2	5.0	5.2
242	PI 169280	Turkey	3.7	8.0	0.7	5	2.3	3.7	5.2
243	PI 181938	Syria	3.8	7.0	0.0	5	2.5	3.7	5.2
244	PI 210017	India	4.8	9.0	2.1	5	4.2	5.2	5.2
245	PI 249008	Nigeria	3.5	9.0	0.0	5	1.7	3.7	5.2
246	PI 270306	Philippines	4.5	8.0	2.1	5	4.0	4.3	5.2
247	PI 306365	Taiwan	4.7	7.0	0.0	5	4.5	4.3	5.2
248	PI 357668	Yugoslavia	4.3	9.0	0.0	5	3.2	4.7	5.2
249	PI 357708	Yugoslavia	4.3	7.0	0.0	5	3.8	4.0	5.2
250	PI 357736	Yugoslavia	4.2	7.0	0.0	5	3.3	4.0	5.2
251	PI 368513	Yugoslavia	4.6	8.0	0.7	5	3.8	4.8	5.2
252	PI 370423	Yugoslavia	4.6	8.0	2.1	5	3.5	5.0	5.2
253	PI 388770	Morocco	3.9	6.0	0.0	5	2.8	3.8	5.2
254	PI 438674	Mexico	4.1	7.0	0.7	5	2.5	4.5	5.2
255	PI 438677	Mexico	4.4	7.0	0.7	5	3.7	4.3	5.2
256	PI 176486	Turkey	4.6	7.0	0.0	6	3.5	5.2	5.2
257	PI 176917	Turkey	3.9	8.0	0.7	6	2.8	3.8	5.2
258	PI 222184	Afghanistan	4.2	7.0	0.0	6	2.8	4.5	5.2
259	PI 254738	Senegal	4.1	7.0	2.1	6	2.8	4.3	5.2
260	PI 266027	Venezuela	3.8	6.0	0.7	6	2.7	3.7	5.2
261	PI 271771	South Africa	3.6	8.0	1.4	6	2.7	3.0	5.2
262	PI 274035	South Africa	4.3	7.0	0.7	6	3.2	4.5	5.2
263	PI 277980	Turkey	4.6	9.0	1.4	6	3.8	4.7	5.2
264	PI 296332	South Africa	4.0	7.0	0.7	6	2.8	4.0	5.2
265	PI 357718	Yugoslavia	4.3	9.0	3.5	6	3.0	4.8	5.2
266	PI 368508	Yugoslavia	4.5	7.0	1.4	6	3.3	5.0	5.2
267	PI 379245	Yugoslavia	4.4	7.0	0.0	6	3.2	4.8	5.2
268	PI 438675	Mexico	3.9	7.0	0.0	6	2.5	4.0	5.2
269	PI 459075	Botswana	3.5	9.0	4.9	6	2.2	3.2	5.2

Appendix1 continued

270	PI 464872	China	3.9	6.0	1.4	6	2.7	4.0	5.2
271	PI 482251	Zimbabwe	4.1	7.0	1.4	6	2.5	4.5	5.2
272	PI 482254	Zimbabwe	3.7	7.0	0.0	6	2.3	3.7	5.2
273	PI 482304	Zimbabwe	3.6	7.0	2.1	6	1.8	3.7	5.2
274	PI 482306	Zimbabwe	3.7	7.0	0.7	6	2.0	3.8	5.2
275	PI 482323	Zimbabwe	4.4	8.0	0.7	6	3.7	4.5	5.2
276	PI 482330	Zimbabwe	3.7	7.0	2.1	6	2.0	3.8	5.2
277	PI 482347	Zimbabwe	3.9	7.0	0.0	6	2.5	4.2	5.2
278	PI 482368	Zimbabwe	4.3	7.0	0.0	6	3.2	4.5	5.2
279	PI 482379	Zimbabwe	4.3	7.0	0.0	6	3.7	4.2	5.2
280	PI 500336	Zambia	4.4	7.0	0.7	6	3.5	4.7	5.2
281	PI 512381	Spain	4.1	7.0	0.7	6	3.2	4.0	5.2
282	PI 532659	Zimbabwe	4.1	8.0	1.4	6	2.8	4.3	5.2
283	PI 532730	Zimbabwe	3.9	8.0	1.4	6	2.5	4.0	5.2
284	PI 560014	Nigeria	3.3	7.0	0.7	6	1.0	3.7	5.2
285	PI 560019	Nigeria	3.7	9.0	0.0	6	2.0	4.0	5.2
286	PI 596670	South Africa	4.1	6.0	0.7	6	3.0	4.0	5.2
287	PI 632755	France	4.1	7.0	1.4	6	3.0	4.0	5.2
288	PI 211851	Iran	4.8	9.0	0.0	4	4.3	4.7	5.2
289	PI 296341	South Africa	3.4	6.0	0.0	3	1.8	3.3	5.3
290	PI 600792	United States	4.6	7.0	0.0	3	3.5	5.0	5.3
291	PI 225557	Zimbabwe	4.5	7.0	0.7	4	3.8	4.5	5.3
292	PI 270565	South Africa	4.6	9.0	2.8	4	3.5	5.0	5.3
293	PI 549161	Chad	4.3	9.0	0.0	3	3.2	4.3	5.3
294	PI 296339	South Africa	3.3	6.0	1.4	4	1.7	3.0	5.3
295	Grif 5596	India	5.0	8.0	0.7	5	4.0	5.7	5.3
296	PI 169236	Turkey	4.4	7.0	1.4	5	3.3	4.7	5.3
297	PI 169237	Turkey	4.9	8.0	0.7	5	3.8	5.5	5.3
298	PI 174105	Turkey	5.0	7.0	0.0	5	4.3	5.3	5.3
299	PI 222713	Iran	4.5	9.0	0.7	5	3.5	4.7	5.3
300	PI 254431	Lebanon	4.2	8.0	1.4	5	2.7	4.5	5.3
301	PI 368514	Yugoslavia	4.6	8.0	2.1	5	3.8	4.7	5.3
302	PI 368528	Yugoslavia	4.6	7.0	1.4	5	3.7	4.7	5.3
303	PI 379255	Yugoslavia	4.3	9.0	0.0	5	3.0	4.5	5.3
304	PI 385964	Kenya	4.3	7.0	2.1	5	3.3	4.3	5.3
305	PI 479704	United States	4.6	8.0	0.0	5	3.7	4.7	5.3
306	PI 482250	Zimbabwe	4.7	7.0	0.0	5	3.7	5.0	5.3
307	PI 482340	Zimbabwe	4.3	7.0	0.7	5	2.5	5.2	5.3
308	PI 482349	Zimbabwe	4.2	9.0	3.5	5	2.3	4.8	5.3

Appendix1 continued

309	PI 490380	Mali	4.5	8.0	0.7	5	3.3	4.8	5.3
310	PI 494532	Nigeria	3.7	9.0	0.0	5	1.7	4.2	5.3
311	PI 556994	United States	3.9	9.0	0.7	5	2.0	4.3	5.3
312	PI 559993	Nigeria	4.3	7.0	1.4	5	3.2	4.5	5.3
313	PI 559999	Nigeria	4.7	9.0	2.8	5	4.2	4.7	5.3
314	PI 629101	China	3.9	8.0	3.5	5	2.5	3.8	5.3
315	PI 179879	India	4.9	9.0	2.1	6	5.0	4.5	5.3
316	PI 200732	El Salvador	4.5	8.0	2.1	6	3.8	4.3	5.3
317	PI 254623	Sudan	4.3	8.0	2.1	6	2.8	4.8	5.3
318	PI 254735	Senegal	4.2	9.0	1.4	6	3.0	4.3	5.3
319	PI 271985	Somalia	4.4	8.0	2.8	6	3.7	4.3	5.3
320	PI 277977	Turkey	4.1	9.0	0.0	6	2.8	4.2	5.3
321	PI 319212	Egypt	4.7	9.0	0.0	6	3.7	5.0	5.3
322	PI 326516	Ghana	4.3	8.0	1.4	6	3.3	4.2	5.3
323	PI 368502	Yugoslavia	4.7	7.0	0.0	6	3.8	4.8	5.3
324	PI 379227	Yugoslavia	4.5	9.0	0.0	6	3.3	4.8	5.3
325	PI 379251	Yugoslavia	4.0	7.0	0.0	6	3.0	3.7	5.3
326	PI 381717	India	4.5	9.0	2.8	6	3.7	4.5	5.3
327	PI 435990	China	4.3	9.0	1.4	6	2.5	5.0	5.3
328	PI 482260	Zimbabwe	3.8	7.0	1.4	6	2.5	3.7	5.3
329	PI 482280	Zimbabwe	4.3	7.0	1.4	6	3.0	4.7	5.3
330	PI 482281	Zimbabwe	3.7	7.0	0.0	6	1.7	4.0	5.3
331	PI 482345	Zimbabwe	3.9	8.0	2.1	6	2.5	4.0	5.3
332	PI 482346	Zimbabwe	4.0	7.0	1.4	6	2.8	3.8	5.3
333	PI 482364	Zimbabwe	3.9	7.0	0.7	6	2.2	4.2	5.3
334	PI 482371	Zimbabwe	3.9	7.0	0.7	6	2.3	4.2	5.3
335	PI 500304	Zambia	3.6	8.0	0.0	6	1.5	3.8	5.3
336	PI 500315	Zambia	4.1	9.0	0.7	6	1.8	5.0	5.3
337	PI 505587	Zambia	4.2	9.0	4.2	6	3.3	3.8	5.3
338	PI 560009	Nigeria	4.1	9.0	2.8	6	2.8	4.2	5.3
339	PI 560024	Nigeria	4.2	9.0	0.0	6	2.3	4.8	5.3
340	PI 593355	China	4.3	8.0	1.4	6	3.3	4.2	5.3
341	PI 593379	China	4.6	8.0	2.1	6	3.8	4.5	5.3
342	Early Canada	United States	3.8	8.0	0.0	4	2.2	4.3	5.4
343	PI 635613	United States	4.9	8.0	0.0	4	4.2	5.3	5.4
344	Quetzali	United States	4.2	7.0	0.0	5	3.8	4.0	5.4
345	PI 593344	China	4.3	6.0	.	1	3.5	4.0	5.5
346	Moon & Stars	United States	3.0	7.0	2.1	2	1.5	2.0	5.5
347	PI 171392	South Africa	4.5	7.0	0.0	2	2.5	5.5	5.5

Appendix1 continued

348	PI 542118	Botswana	4.2	7.0	0.0	2	3.5	3.5	5.5
349	PI 229605	Iran	5.0	8.0	.	3	4.5	5.0	5.5
350	PI 485579	Zimbabwe	4.6	7.0	.	3	3.8	4.5	5.5
351	PI 169272	Turkey	4.6	8.0	0.0	4	3.3	4.8	5.5
352	PI 175661	Turkey	5.3	8.0	.	4	5.0	5.3	5.5
353	PI 295848	South Africa	4.5	8.0	.	4	3.0	5.0	5.5
354	PI 320988	Sierra Leone	4.8	8.0	0.0	4	4.5	4.3	5.5
355	PI 368515	Yugoslavia	3.9	7.0	0.7	4	2.0	4.2	5.5
356	PI 482249	Zimbabwe	4.9	7.0	.	4	3.8	5.5	5.5
357	PI 505935	Zambia	3.8	8.0	0.7	4	2.5	3.3	5.5
358	PI 532811	China	4.8	8.0	0.7	4	4.2	4.8	5.5
359	PI 593356	China	3.6	7.0	0.0	4	1.5	3.8	5.5
360	PI 596691	South Africa	4.6	7.0	0.0	4	3.2	5.2	5.5
361	Royal Sweet	United States	4.1	7.0	1.4	4	2.8	4.0	5.5
362	Sweet heart	United States	5.2	7.0	2.1	4	4.8	5.3	5.5
363	PI 165024	Turkey	5.0	7.0	2.1	5	5.0	4.5	5.5
364	PI 169293	Turkey	4.8	9.0	0.0	5	3.7	5.2	5.5
365	PI 169297	Turkey	4.6	9.0	2.8	5	3.5	4.7	5.5
366	PI 246029	Chile	4.9	8.0	0.0	5	4.2	5.0	5.5
367	PI 246559	Senegal	4.4	9.0	0.0	5	3.2	4.5	5.5
368	PI 270563	South Africa	4.1	7.0	0.7	5	2.7	4.0	5.5
369	PI 271987	Somalia	3.9	9.0	0.7	5	2.7	3.5	5.5
370	PI 278007	Turkey	4.8	9.0	0.0	5	4.2	4.8	5.5
371	PI 278025	Turkey	4.4	8.0	2.1	5	3.3	4.3	5.5
372	PI 279462	Japan	4.6	7.0	0.7	5	3.7	4.5	5.5
373	PI 345547	Ukraine	4.4	7.0	0.0	5	3.7	4.2	5.5
374	PI 357692	Yugoslavia	3.8	8.0	0.7	5	2.7	3.2	5.5
375	PI 357727	Yugoslavia	4.6	7.0	0.7	5	3.5	4.7	5.5
376	PI 368500	Yugoslavia	4.8	8.0	0.7	5	3.7	5.2	5.5
377	PI 379232	Yugoslavia	5.4	9.0	0.0	5	5.5	5.3	5.5
378	PI 379248	Yugoslavia	4.8	8.0	0.7	5	3.8	5.2	5.5
379	PI 476329	Soviet Union	4.3	7.0	1.4	5	3.2	4.3	5.5
380	PI 482264	Zimbabwe	3.3	7.0	1.4	5	0.7	3.7	5.5
381	PI 482297	Zimbabwe	4.0	7.0	1.4	5	2.3	4.2	5.5
382	PI 482374	Zimbabwe	4.3	7.0	0.7	5	2.5	4.8	5.5
383	PI 491265	Zimbabwe	4.5	7.0	0.0	5	3.3	4.7	5.5
384	PI 500318	Zambia	4.3	9.0	2.8	5	2.8	4.7	5.5
385	PI 512348	Spain	3.3	9.0	0.7	5	0.8	3.5	5.5
386	PI 512370	Spain	4.2	8.0	0.7	5	3.3	3.7	5.5

Appendix1 continued

387	PI 512395	Spain	4.4	7.0	0.0	5	3.3	4.5	5.5
388	PI 525098	Egypt	4.4	9.0	0.7	5	3.3	4.5	5.5
389	PI 526234	Zimbabwe	4.2	7.0	0.0	5	2.3	4.8	5.5
390	PI 542616	Algeria	4.8	7.0	0.0	5	3.7	5.2	5.5
391	PI 560010	Nigeria	3.4	7.0	0.0	5	1.2	3.7	5.5
392	Peacock Shipper	United States	4.4	7.0	0.0	5	3.3	4.3	5.5
393	PI 169278	Turkey	4.2	8.0	2.1	6	2.0	5.0	5.5
394	PI 176489	Turkey	4.3	7.0	0.0	6	3.5	4.0	5.5
395	PI 177325	Turkey	4.4	8.0	2.8	6	3.3	4.5	5.5
396	PI 179233	Turkey	4.4	9.0	0.0	6	3.3	4.3	5.5
397	PI 180277	India	4.2	7.0	1.4	6	2.8	4.2	5.5
398	PI 182177	Turkey	4.7	8.0	0.7	6	3.7	5.0	5.5
399	PI 203551	United States	4.6	7.0	0.7	6	4.2	4.2	5.5
400	PI 254739	Senegal	4.2	7.0	0.0	6	2.8	4.3	5.5
401	PI 271778	South Africa	4.3	8.0	2.1	6	3.0	4.5	5.5
402	PI 277995	Turkey	4.8	7.0	0.0	6	4.5	4.5	5.5
403	PI 277998	Turkey	4.2	7.0	0.7	6	2.7	4.5	5.5
404	PI 279458	Japan	3.9	9.0	0.0	6	2.3	4.0	5.5
405	PI 296334	South Africa	4.0	7.0	1.4	6	2.0	4.5	5.5
406	PI 357679	Yugoslavia	3.8	7.0	0.7	6	2.5	3.5	5.5
407	PI 357691	Yugoslavia	4.8	8.0	0.0	6	3.8	5.2	5.5
408	PI 357711	Yugoslavia	4.6	8.0	2.8	6	3.7	4.7	5.5
409	PI 357712	Yugoslavia	4.3	7.0	1.4	6	3.3	4.2	5.5
410	PI 364460	South Africa	3.9	7.0	0.0	6	2.3	3.8	5.5
411	PI 378611	Zaire	4.8	7.0	0.7	6	4.0	5.0	5.5
412	PI 381733	India	5.4	9.0	2.1	6	5.2	5.5	5.5
413	PI 381746	India	4.9	7.0	0.0	6	4.2	5.0	5.5
414	PI 381753	India	5.0	7.0	0.0	6	4.5	5.0	5.5
415	PI 482256	Zimbabwe	3.8	8.0	1.4	6	2.0	3.8	5.5
416	PI 482343	Zimbabwe	4.2	8.0	1.4	6	2.8	4.2	5.5
417	PI 482350	Zimbabwe	4.4	7.0	0.7	6	3.0	4.7	5.5
418	PI 482363	Zimbabwe	4.3	8.0	2.8	6	2.8	4.7	5.5
419	PI 482381	Zimbabwe	4.1	7.0	0.7	6	2.0	4.7	5.5
420	PI 500305	Zambia	4.3	9.0	2.1	6	2.5	4.8	5.5
421	PI 500337	Zambia	4.5	7.0	0.7	6	3.5	4.5	5.5
422	PI 500338	Zambia	3.9	7.0	0.7	6	1.8	4.3	5.5
423	PI 500349	Zambia	3.8	7.0	0.7	6	2.0	4.0	5.5
424	PI 502319	Uzbekistan	4.2	7.0	0.7	6	2.8	4.3	5.5
425	PI 508444	South Korea	4.4	8.0	2.1	6	3.7	4.2	5.5

Appendix1 continued

426	PI 512331	China	4.3	7.0	0.7	6	2.8	4.5	5.5
427	PI 512389	Spain	4.6	8.0	0.7	6	3.7	4.7	5.5
428	PI 526232	Zimbabwe	4.4	8.0	0.7	6	2.8	4.8	5.5
429	PI 534595	Syria	4.3	7.0	0.0	6	3.3	4.0	5.5
430	PI 595200	United States	3.5	8.0	2.1	6	1.5	3.5	5.5
431	PI 612460	South Korea	4.1	7.0	1.4	6	2.5	4.2	5.5
432	PI 269464	Pakistan	5.1	7.0	0.0	2	4.5	5.2	5.6
433	PI 212208	Greece	5.8	5.0	0.0	1	5.8	6.1	5.6
434	PI 169239	Turkey	4.7	7.0	0.0	4	3.8	4.8	5.6
435	PI 174106	Turkey	4.1	7.0	0.7	5	3.0	4.2	5.6
436	PI 635614	United States	4.3	9.0	0.0	5	3.5	4.3	5.6
437	PI 254430	Lebanon	4.9	7.0	.	3	3.0	6.0	5.7
438	PI 357664	Yugoslavia	4.9	8.0	0.0	3	4.0	5.0	5.7
439	PI 171581	Turkey	4.4	9.0	0.0	4	2.8	4.7	5.7
440	PI 175654	Turkey	4.3	7.0	0.0	4	3.0	4.2	5.7
441	PI 176912	Turkey	4.4	7.0	0.0	4	2.7	4.8	5.7
442	PI 211915	Iran	4.5	7.0	0.0	4	3.0	4.8	5.7
443	PI 368524	Yugoslavia	4.6	7.0	0.0	4	3.8	4.2	5.7
444	PI 379228	Yugoslavia	4.7	7.0	1.4	4	3.5	4.8	5.7
445	PI 171580	Turkey	5.6	9.0	0.7	5	5.5	5.5	5.7
446	PI 185030	Turkey	4.9	9.0	0.0	5	4.3	4.8	5.7
447	PI 193490	Ethiopia	4.4	7.0	0.0	5	2.8	4.7	5.7
448	PI 217937	Pakistan	4.4	9.0	4.2	5	3.3	4.3	5.7
449	PI 357683	Yugoslavia	4.3	7.0	0.0	5	3.3	4.0	5.7
450	PI 357690	Yugoslavia	4.3	8.0	0.7	5	3.2	4.0	5.7
451	PI 357722	Yugoslavia	5.2	9.0	1.4	5	4.5	5.5	5.7
452	PI 357740	Yugoslavia	4.3	8.0	0.0	5	3.3	4.0	5.7
453	PI 357750	Yugoslavia	4.7	8.0	0.0	5	3.5	5.0	5.7
454	PI 368503	Yugoslavia	4.4	7.0	0.0	5	3.8	3.8	5.7
455	PI 368525	Yugoslavia	4.4	9.0	0.0	5	3.5	4.0	5.7
456	PI 370430	Yugoslavia	4.6	7.0	0.0	5	3.3	4.8	5.7
457	PI 378616	Zaire	4.4	7.0	0.0	5	3.2	4.3	5.7
458	PI 381695	India	5.0	7.0	0.0	5	4.0	5.3	5.7
459	PI 482285	Zimbabwe	5.3	7.0	0.0	5	4.3	5.8	5.7
460	PI 482289	Zimbabwe	4.3	8.0	0.0	5	2.7	4.7	5.7
461	PI 482314	Zimbabwe	4.5	8.0	1.4	5	2.7	5.2	5.7
462	PI 482317	Zimbabwe	4.7	9.0	0.0	5	2.7	5.7	5.7
463	PI 500311	Zambia	5.0	7.0	0.0	5	4.0	5.3	5.7
464	PI 500341	Zambia	4.6	7.0	0.0	5	4.2	4.0	5.7

Appendix1 continued

465	PI 534531	Syria	4.7	7.0	0.7	5	4.0	4.5	5.7
466	PI 593348	China	4.3	8.0	0.0	5	2.7	4.7	5.7
467	PI 169238	Turkey	4.7	7.0	0.7	6	4.0	4.5	5.7
468	PI 169255	Turkey	4.0	7.0	0.0	6	2.7	3.7	5.7
469	PI 169268	Turkey	4.1	7.0	0.7	6	2.7	4.0	5.7
470	PI 172786	Turkey	4.3	7.0	0.7	6	2.8	4.3	5.7
471	PI 174812	India	5.1	7.0	0.0	6	4.7	5.0	5.7
472	PI 175665	Turkey	4.7	9.0	0.0	6	3.2	5.2	5.7
473	PI 176909	Turkey	4.5	8.0	0.0	6	3.5	4.3	5.7
474	PI 185636	Ghana	4.1	8.0	0.7	6	2.7	4.0	5.7
475	PI 227203	Japan	4.6	9.0	0.0	6	3.2	4.8	5.7
476	PI 234603	United States	4.3	8.0	1.4	6	3.3	4.0	5.7
477	PI 247398	Greece	4.5	9.0	0.0	6	3.2	4.7	5.7
478	PI 249009	Nigeria	4.2	9.0	2.1	6	2.7	4.2	5.7
479	PI 254742	Senegal	4.3	8.0	0.7	6	3.2	4.0	5.7
480	PI 254743	Senegal	4.4	7.0	2.1	6	3.5	4.2	5.7
481	PI 270308	Philippines	4.3	9.0	1.4	6	3.0	4.3	5.7
482	PI 270551	Ghana	4.3	7.0	0.7	6	2.8	4.3	5.7
483	PI 273481	Ethiopia	4.6	7.0	0.7	6	3.5	4.5	5.7
484	PI 277993	Turkey	4.9	8.0	2.1	6	4.2	5.0	5.7
485	PI 278014	Turkey	5.2	7.0	0.7	6	4.7	5.2	5.7
486	PI 278017	Turkey	4.3	8.0	0.7	6	2.7	4.5	5.7
487	PI 278026	Turkey	4.0	7.0	1.4	6	2.5	3.8	5.7
488	PI 346787	United States	4.4	7.0	2.1	6	3.7	4.0	5.7
489	PI 357661	Yugoslavia	4.9	8.0	1.4	6	4.2	5.0	5.7
490	PI 357675	Yugoslavia	4.6	7.0	0.0	6	3.5	4.5	5.7
491	PI 357677	Yugoslavia	4.3	7.0	1.4	6	3.3	4.0	5.7
492	PI 381734	India	5.1	9.0	0.0	6	4.0	5.5	5.7
493	PI 381743	India	5.3	7.0	0.0	6	5.0	5.3	5.7
494	PI 381754	India	4.8	7.0	0.7	6	4.2	4.7	5.7
495	PI 420320	Italy	4.5	7.0	1.4	6	3.3	4.5	5.7
496	PI 470248	Indonesia	4.9	7.0	0.0	6	4.2	4.8	5.7
497	PI 476330	Soviet Union	4.8	7.0	0.7	6	3.8	5.0	5.7
498	PI 482295	Zimbabwe	3.9	7.0	1.4	6	2.0	4.2	5.7
499	PI 482337	Zimbabwe	3.8	7.0	0.7	6	1.8	4.0	5.7
500	PI 482344	Zimbabwe	4.5	8.0	0.7	6	2.8	5.0	5.7
501	PI 482348	Zimbabwe	4.4	7.0	0.0	6	3.2	4.3	5.7
502	PI 482370	Zimbabwe	4.1	7.0	0.0	6	2.5	4.0	5.7
503	PI 494816	Zambia	3.8	7.0	0.7	6	1.7	4.0	5.7

Appendix1 continued

504	PI 494820	Zambia	4.2	8.0	0.0	6	2.0	5.0	5.7
505	PI 500309	Zambia	3.8	8.0	3.5	6	1.8	3.8	5.7
506	PI 500347	Zambia	4.9	9.0	0.7	6	3.7	5.3	5.7
507	PI 505592	Zambia	4.1	8.0	0.7	6	2.8	3.7	5.7
508	PI 512362	Spain	4.6	7.0	0.7	6	3.8	4.3	5.7
509	PI 526236	Zimbabwe	4.4	9.0	2.1	6	2.8	4.8	5.7
510	PI 526237	Zimbabwe	4.2	7.0	1.4	6	2.5	4.3	5.7
511	PI 534597	Syria	4.6	8.0	1.4	6	3.3	4.7	5.7
512	PI 540911	Unknown	5.1	7.0	0.7	6	4.3	5.3	5.7
513	PI 593345	China	4.4	7.0	2.1	6	3.3	4.2	5.7
514	PI 593368	China	4.7	8.0	0.7	6	3.7	4.8	5.7
515	PI 601141	United States	4.4	9.0	0.0	6	3.0	4.5	5.7
516	PI 612458	Koreas	4.7	8.0	0.7	6	3.7	4.7	5.7
517	Grif 1733	China	4.5	7.0	.	3	2.8	5.0	5.8
518	PI 379225	Yugoslavia	5.1	8.0	.	3	4.0	5.5	5.8
519	PI 560017	Nigeria	3.9	8.0	0.0	3	2.0	4.0	5.8
520	PI 512385	Spain	4.8	7.0	0.7	4	3.8	4.8	5.8
521	PI 357709	Yugoslavia	4.5	8.0	0.0	5	2.7	5.2	5.8
522	PI 629102	United States	4.9	7.0	0.7	5	3.8	5.3	5.8
523	PI 635601	United States	4.6	8.0	2.1	5	4.0	4.3	5.8
524	PI 542123	Botswana	4.9	8.0	1.4	3	3.8	5.2	5.8
525	PI 229604	Iran	4.5	9.0	0.7	4	3.0	4.7	5.8
526	PI 278002	Turkey	4.7	7.0	0.7	4	3.0	5.2	5.8
527	PI 357735	Yugoslavia	5.4	9.0	1.4	4	5.0	5.5	5.8
528	PI 482310	Zimbabwe	4.3	9.0	2.1	4	2.2	4.8	5.8
529	PI 490378	Mali	4.7	8.0	0.7	4	4.0	4.3	5.8
530	PI 512400	Spain	4.6	8.0	0.0	4	3.3	4.5	5.8
531	PI 164737	India	5.4	9.0	2.1	5	5.2	5.3	5.8
532	PI 174099	Turkey	4.9	9.0	0.0	5	3.8	5.0	5.8
533	PI 176923	Turkey	5.4	8.0	0.7	5	4.8	5.5	5.8
534	PI 179235	Turkey	5.0	9.0	1.4	5	3.7	5.5	5.8
535	PI 179875	India	4.8	7.0	0.0	5	3.8	4.7	5.8
536	PI 179882	India	4.8	8.0	0.7	5	3.8	4.7	5.8
537	PI 181743	Lebanon	4.2	7.0	0.0	5	3.0	3.8	5.8
538	PI 182180	Turkey	4.9	9.0	0.0	5	4.7	4.3	5.8
539	PI 250145	Pakistan	5.3	7.0	0.7	5	5.2	4.8	5.8
540	PI 271466	India	4.6	8.0	0.0	5	3.5	4.3	5.8
541	PI 271777	South Africa	4.1	7.0	0.0	5	2.2	4.3	5.8
542	PI 271984	Somalia	4.6	9.0	0.0	5	3.2	4.7	5.8

Appendix1 continued

543	PI 278027	Turkey	4.7	9.0	0.0	5	3.8	4.3	5.8
544	PI 278028	Turkey	4.9	9.0	0.0	5	4.2	4.8	5.8
545	PI 279459	Japan	4.3	8.0	0.0	5	2.7	4.3	5.8
546	PI 279460	Japan	4.9	7.0	0.0	5	3.7	5.3	5.8
547	PI 357728	Yugoslavia	4.2	8.0	0.7	5	2.7	4.0	5.8
548	PI 378617	Zaire	4.8	7.0	0.0	5	3.3	5.2	5.8
549	PI 379249	Yugoslavia	4.8	7.0	0.0	5	3.8	4.8	5.8
550	PI 381698	India	4.8	9.0	3.5	5	4.0	4.7	5.8
551	PI 381711	India	4.8	9.0	0.0	5	3.3	5.3	5.8
552	PI 482255	Zimbabwe	4.5	8.0	0.0	5	3.5	4.2	5.8
553	PI 482365	Zimbabwe	4.5	8.0	1.4	5	3.2	4.5	5.8
554	PI 500343	Zambia	4.2	8.0	1.4	5	2.5	4.2	5.8
555	PI 505584	Zambia	4.1	7.0	0.0	5	2.3	4.0	5.8
556	PI 526235	Zimbabwe	4.2	8.0	0.0	5	2.3	4.5	5.8
557	PI 537270	Pakistan	5.0	8.0	0.0	5	4.5	4.7	5.8
558	PI 540917	Unknown	4.8	7.0	0.0	5	4.0	4.7	5.8
559	PI 560016	Nigeria	5.3	9.0	0.0	5	4.2	5.8	5.8
560	PI 561138	Kazakhstan	4.6	8.0	0.7	5	3.7	4.3	5.8
561	PI 593373	China	4.4	8.0	2.1	5	3.2	4.3	5.8
562	PI 593383	China	4.9	7.0	0.0	5	4.0	5.0	5.8
563	PI 593389	China	4.8	7.0	0.0	5	3.3	5.3	5.8
564	PI 612469	South Korea	4.2	8.0	1.4	5	3.0	3.7	5.8
565	Grif 1731	China	4.5	9.0	0.7	6	3.3	4.3	5.8
566	PI 165448	Mexico	4.8	8.0	2.8	6	3.8	4.7	5.8
567	PI 169233	Turkey	4.9	8.0	0.0	6	4.0	5.0	5.8
568	PI 181740	Lebanon	4.6	8.0	1.4	6	3.0	4.8	5.8
569	PI 182178	Turkey	5.0	9.0	0.0	6	4.0	5.2	5.8
570	PI 189318	Nigeria	3.7	8.0	2.8	6	1.8	3.5	5.8
571	PI 260733	Sudan	4.7	9.0	0.7	6	2.8	5.3	5.8
572	PI 271983	Somalia	5.0	9.0	1.4	6	3.8	5.3	5.8
573	PI 277975	Turkey	4.6	8.0	0.7	6	3.8	4.2	5.8
574	PI 277976	Turkey	4.1	8.0	0.7	6	2.5	4.0	5.8
575	PI 278000	Turkey	4.8	8.0	0.7	6	4.0	4.7	5.8
576	PI 278050	Turkey	4.6	8.0	0.7	6	3.5	4.5	5.8
577	PI 278057	Turkey	4.6	7.0	0.7	6	3.3	4.5	5.8
578	PI 307750	Philippines	4.6	7.0	0.0	6	3.5	4.3	5.8
579	PI 357660	Yugoslavia	3.9	7.0	0.0	6	1.7	4.2	5.8
580	PI 357707	Yugoslavia	4.8	7.0	1.4	6	3.8	4.7	5.8
581	PI 368522	Yugoslavia	4.9	7.0	0.0	6	3.8	5.0	5.8

Appendix1 continued

582	PI 386018	Iran	4.7	9.0	2.8	6	3.5	4.8	5.8
583	PI 482253	Zimbabwe	4.8	7.0	0.7	6	4.0	4.5	5.8
584	PI 482270	Zimbabwe	4.6	7.0	0.0	6	3.5	4.5	5.8
585	PI 482325	Zimbabwe	4.2	9.0	1.4	6	2.5	4.3	5.8
586	PI 494817	Zambia	5.9	9.0	3.5	6	5.8	6.0	5.8
587	PI 500312	Zambia	4.4	8.0	1.4	6	3.0	4.5	5.8
588	PI 502315	Ukraine	4.6	8.0	0.0	6	3.3	4.5	5.8
589	PI 505586	Zambia	4.6	9.0	2.1	6	3.3	4.5	5.8
590	PI 505593	Zambia	4.4	8.0	0.7	6	3.2	4.3	5.8
591	PI 507858	Hungary	4.6	8.0	0.0	6	3.8	4.2	5.8
592	PI 512339	Spain	4.2	7.0	0.7	6	3.0	3.7	5.8
593	PI 512343	Spain	4.6	9.0	0.0	6	3.7	4.3	5.8
594	PI 512356	Spain	4.2	7.0	0.7	6	2.7	4.2	5.8
595	PI 512388	Spain	4.4	7.0	1.4	6	3.0	4.3	5.8
596	PI 518606	Russia	4.6	9.0	0.0	6	3.2	4.8	5.8
597	PI 532818	China	4.6	8.0	0.0	6	3.0	5.0	5.8
598	PI 560003	Nigeria	4.5	9.0	0.0	6	3.0	4.7	5.8
599	PI 593349	China	4.6	7.0	0.7	6	3.2	4.7	5.8
600	PI 593361	China	4.8	9.0	1.4	6	3.5	5.0	5.8
601	PI 593370	China	4.7	8.0	0.0	6	3.7	4.7	5.8
602	PI 593390	China	4.6	9.0	0.0	6	3.3	4.5	5.8
603	PI 595218	United States	4.3	7.0	1.4	6	2.7	4.3	5.8
604	PI 600951	United States	4.5	7.0	0.7	6	3.3	4.3	5.8
605	PI 612457	South Koreas	4.6	7.0	1.4	6	3.7	4.2	5.8
606	PI 629110	United States	5.2	9.0	2.1	6	4.3	5.5	5.8
607	PI 295845	South Africa	5.0	5.0	.	0	4.0	5.0	6.0
608	Blacklee2	United States	4.7	6.0	0.0	1	4.0	4.0	6.0
609	PI 271363	India	4.7	6.0	0.0	1	4.0	4.0	6.0
610	PI 374216	Afghanistan	5.3	6.0	.	1	4.0	6.0	6.0
611	PI 490383	Mali	6.3	7.0	.	1	6.0	7.0	6.0
612	PI 542119	Botswana	6.0	7.0	.	1	7.0	5.0	6.0
613	Desert King	United States	6.7	8.0	.	2	6.5	7.5	6.0
614	PI 169267	Turkey	6.7	8.0	.	2	6.5	7.5	6.0
615	PI 183022	India	5.3	7.0	.	2	4.0	6.0	6.0
616	PI 270143	India	3.7	7.0	0.0	2	3.0	2.0	6.0
617	Red-N-Sweet	United States	4.0	6.0	0.0	2	3.0	3.0	6.0
618	Allsweet	United States	3.8	7.0	0.0	3	2.3	3.3	6.0
619	PI 270546	Ghana	5.3	7.0	0.0	3	4.3	5.7	6.0
620	PI 357748	Yugoslavia	4.7	7.0	1.4	3	3.5	4.7	6.0

Appendix1 continued

621	PI 381720	India	4.8	9.0	.	3	3.3	5.0	6.0
622	PI 167124	Turkey	4.7	9.0	0.0	4	4.0	4.0	6.0
623	PI 169248	Turkey	4.6	8.0	0.0	4	3.5	4.3	6.0
624	PI 176910	Turkey	4.8	7.0	0.0	4	4.2	4.2	6.0
625	PI 229806	United States	4.8	7.0	0.0	4	3.3	5.2	6.0
626	PI 326515	Ghana	5.1	8.0	0.0	4	4.3	5.0	6.0
627	PI 344298	Turkey	4.8	9.0	0.0	4	4.0	4.5	6.0
628	PI 357674	Yugoslavia	4.7	9.0	0.0	4	3.5	4.7	6.0
629	PI 357729	Yugoslavia	4.3	8.0	0.0	4	3.0	4.0	6.0
630	PI 379256	Yugoslavia	4.8	8.0	0.0	4	3.8	4.7	6.0
631	PI 490385	Mali	4.4	7.0	0.0	4	2.5	4.8	6.0
632	PI 508443	South Korea	4.1	7.0	0.0	4	2.0	4.2	6.0
633	PI 525096	Egypt	4.7	7.0	1.4	4	3.7	4.3	6.0
634	Grif 5602	India	5.4	7.0	0.7	5	5.2	5.2	6.0
635	PI 164709	India	5.1	7.0	0.0	5	4.5	4.8	6.0
636	PI 167222	Turkey	4.8	9.0	0.0	5	3.8	4.5	6.0
637	PI 169240	Turkey	4.6	8.0	0.7	5	3.5	4.3	6.0
638	PI 169270	Turkey	4.7	9.0	0.7	5	3.8	4.2	6.0
639	PI 172789	Turkey	4.6	8.0	2.1	5	3.3	4.5	6.0
640	PI 172798	Turkey	5.3	9.0	0.7	5	4.8	5.2	6.0
641	PI 174104	Turkey	4.4	7.0	0.0	5	3.0	4.3	6.0
642	PI 179239	Turkey	4.2	8.0	0.7	5	2.5	4.2	6.0
643	PI 179883	India	4.7	8.0	0.7	5	3.7	4.3	6.0
644	PI 186975	Ghana	4.4	9.0	0.7	5	2.8	4.5	6.0
645	PI 192938	China	4.4	7.0	0.7	5	2.7	4.7	6.0
646	PI 193964	Ethiopia	4.5	7.0	0.0	5	3.0	4.5	6.0
647	PI 227202	Japan	4.6	7.0	0.0	5	2.8	5.0	6.0
648	PI 227205	Japan	4.8	7.0	0.0	5	3.5	4.8	6.0
649	PI 229748	Iran	4.2	8.0	1.4	5	2.2	4.5	6.0
650	PI 270562	South Africa	5.0	8.0	1.4	5	4.0	5.0	6.0
651	PI 271751	Ghana	4.7	7.0	0.7	5	3.3	4.8	6.0
652	PI 296384	Iran	5.1	9.0	0.0	5	4.2	5.0	6.0
653	PI 344395	Iran	4.7	7.0	0.0	5	3.2	4.8	6.0
654	PI 357723	Yugoslavia	4.6	8.0	0.7	5	3.5	4.3	6.0
655	PI 368501	Yugoslavia	5.1	9.0	1.4	5	4.2	5.2	6.0
656	PI 368512	Yugoslavia	5.0	8.0	0.7	5	4.0	5.0	6.0
657	PI 370425	Yugoslavia	4.7	9.0	2.8	5	3.7	4.3	6.0
658	PI 370433	Yugoslavia	5.4	7.0	0.0	5	5.0	5.3	6.0
659	PI 379229	Yugoslavia	5.1	9.0	0.0	5	4.2	5.2	6.0

Appendix1 continued

660	PI 379240	Yugoslavia	4.6	8.0	0.0	5	3.3	4.3	6.0
661	PI 379250	Yugoslavia	5.4	9.0	1.4	5	5.0	5.2	6.0
662	PI 381748	India	5.4	7.0	0.0	5	5.0	5.2	6.0
663	PI 386026	Iran	5.2	9.0	0.0	5	4.5	5.0	6.0
664	PI 418762	Afghanistan	4.8	8.0	0.0	5	3.0	5.3	6.0
665	PI 435085	China	5.1	9.0	1.4	5	3.8	5.5	6.0
666	PI 449332	India	5.6	7.0	0.0	5	5.3	5.5	6.0
667	PI 470247	Indonesia	4.5	8.0	0.0	5	2.5	5.0	6.0
668	PI 482275	Zimbabwe	4.1	8.0	3.5	5	2.7	3.5	6.0
669	PI 482287	Zimbabwe	4.7	8.0	0.7	5	3.7	4.3	6.0
670	PI 482375	Zimbabwe	4.6	7.0	0.0	5	2.8	5.0	6.0
671	PI 482376	Zimbabwe	4.5	8.0	0.7	5	3.0	4.5	6.0
672	PI 490382	Mali	5.0	8.0	0.0	5	3.8	5.2	6.0
673	PI 505591	Zambia	4.1	9.0	3.5	5	1.5	4.7	6.0
674	PI 505595	Zambia	4.5	8.0	2.1	5	3.0	4.5	6.0
675	PI 512404	Spain	4.5	9.0	2.1	5	2.8	4.7	6.0
676	PI 532813	China	4.7	8.0	1.4	5	3.0	5.0	6.0
677	PI 534586	Syria	5.1	7.0	0.7	5	4.7	4.5	6.0
678	PI 536449	Maldives	4.8	9.0	1.4	5	4.2	4.3	6.0
679	PI 543209	Bolivia	5.3	8.0	0.7	5	4.5	5.3	6.0
680	PI 596677	South Africa	4.7	7.0	0.0	5	3.5	4.7	6.0
681	PI 612462	South Korea	4.6	7.0	0.0	5	3.0	4.8	6.0
682	PI 612473	South Korea	4.6	8.0	0.7	5	3.5	4.8	6.0
683	PI 635590	United States	5.3	7.0	1.4	5	5.0	4.8	6.0
684	PI 635594	United States	4.9	8.0	0.0	5	3.8	5.0	6.0
685	DMR-113	United States	5.1	8.0	0.7	6	4.3	5.0	6.0
686	PI 173670	Turkey	4.6	9.0	0.0	6	3.7	4.2	6.0
687	PI 175657	Turkey	4.0	9.0	0.0	6	2.7	3.3	6.0
688	PI 179232	Turkey	4.6	9.0	0.7	6	3.3	4.3	6.0
689	PI 179240	Turkey	4.8	9.0	0.0	6	4.3	4.0	6.0
690	PI 181936	Syria	4.9	8.0	0.7	6	3.5	5.3	6.0
691	PI 186489	Nigeria	4.7	9.0	0.0	6	3.2	5.0	6.0
692	PI 186974	Ghana	4.8	9.0	2.8	6	3.5	4.8	6.0
693	PI 193965	Ethiopia	4.4	8.0	1.4	6	2.7	4.5	6.0
694	PI 195562	Ethiopia	4.6	9.0	1.4	6	3.0	4.8	6.0
695	PI 208740	Cuba	4.5	7.0	1.4	6	3.5	4.0	6.0
696	PI 269678	Belize	4.7	8.0	0.7	6	3.5	4.7	6.0
697	PI 277978	Turkey	4.5	8.0	1.4	6	3.2	4.3	6.0
698	PI 277999	Turkey	4.7	9.0	0.0	6	2.8	5.2	6.0

Appendix1 continued

699	PI 278019	Turkey	4.2	9.0	0.0	6	2.3	4.2	6.0
700	PI 293765	Soviet Union	4.3	7.0	0.0	6	2.8	4.0	6.0
701	PI 357682	Yugoslavia	5.3	7.0	0.7	6	4.5	5.5	6.0
702	PI 357688	Yugoslavia	4.7	8.0	2.1	6	3.7	4.5	6.0
703	PI 381705	India	5.1	9.0	0.0	6	4.3	5.0	6.0
704	PI 381731	India	4.8	9.0	0.0	6	4.0	4.5	6.0
705	PI 386015	Iran	5.1	8.0	1.4	6	4.0	5.2	6.0
706	PI 426625	Pakistan	4.8	7.0	0.7	6	4.3	4.0	6.0
707	PI 427298	India	4.9	7.0	0.0	6	4.5	4.3	6.0
708	PI 430615	China	4.9	9.0	2.1	6	4.0	4.8	6.0
709	PI 438671	Mexico	4.7	7.0	0.7	6	3.2	4.8	6.0
710	PI 438673	Mexico	5.0	8.0	0.7	6	4.2	4.8	6.0
711	PI 458738	Paraguay	4.7	8.0	0.7	6	4.3	3.8	6.0
712	PI 482271	Zimbabwe	4.1	8.0	0.0	6	3.0	3.3	6.0
713	PI 494529	Nigeria	4.6	9.0	0.7	6	2.8	5.0	6.0
714	PI 500342	Zambia	4.3	8.0	2.1	6	2.8	4.2	6.0
715	PI 500345	Zambia	4.2	9.0	0.0	6	2.7	3.8	6.0
716	PI 505588	Zambia	3.9	8.0	2.8	6	2.2	3.5	6.0
717	PI 507864	Hungary	4.5	9.0	2.1	6	2.8	4.7	6.0
718	PI 507867	Hungary	4.6	8.0	0.7	6	3.3	4.5	6.0
719	PI 512360	Spain	4.3	8.0	0.7	6	2.8	4.0	6.0
720	PI 512391	Spain	4.6	9.0	0.0	6	2.7	5.2	6.0
721	PI 512399	Spain	4.9	8.0	0.7	6	4.2	4.7	6.0
722	PI 525083	Egypt	4.9	9.0	2.8	6	3.5	5.2	6.0
723	PI 526238	Zimbabwe	4.8	9.0	2.8	6	3.3	5.2	6.0
724	PI 526239	Zimbabwe	4.3	8.0	2.1	6	2.8	4.2	6.0
725	PI 532726	Zimbabwe	4.4	9.0	0.0	6	3.2	4.2	6.0
726	PI 534585	Syria	4.6	8.0	1.4	6	3.3	4.3	6.0
727	PI 534594	Syria	5.2	9.0	1.4	6	4.5	5.0	6.0
728	PI 536544	India	5.0	7.0	0.7	6	4.0	5.0	6.0
729	PI 549162	Chad	4.6	8.0	0.0	6	2.8	4.8	6.0
730	PI 560004	Nigeria	4.1	9.0	0.0	6	2.0	4.2	6.0
731	PI 560005	Nigeria	4.5	9.0	0.7	6	2.7	4.8	6.0
732	PI 585222	United States	4.6	7.0	0.0	6	3.0	4.8	6.0
733	PI 593341	China	4.7	8.0	0.7	6	3.3	4.7	6.0
734	PI 593350	China	4.2	8.0	0.7	6	2.0	4.7	6.0
735	PI 593365	China	4.8	8.0	0.7	6	3.7	4.8	6.0
736	PI 593385	China	4.9	9.0	0.0	6	3.7	5.0	6.0
737	PI 600962	United States	5.1	8.0	0.7	6	4.3	4.8	6.0

Appendix1 continued

738	PI 612459	South Korea	4.6	8.0	0.0	6	3.5	4.3	6.0
739	PI 612464	South Korea	4.7	8.0	1.4	6	3.3	4.7	6.0
740	PI 612468	South Korea	4.7	8.0	0.7	6	3.7	4.3	6.0
741	PI 180275	India	5.4	6.0	0.0	3	4.5	5.6	6.1
742	PI 178876	Turkey	4.8	8.0	0.0	4	4.2	4.0	6.2
743	PI 211917	Iran	5.2	7.0	0.0	4	4.5	5.0	6.2
744	PI 247399	Greece	4.1	8.0	0.7	4	2.0	4.2	6.2
745	PI 357662	Yugoslavia	5.2	8.0	0.7	4	4.3	5.0	6.2
746	PI 357731	Yugoslavia	4.6	9.0	2.1	4	3.0	4.7	6.2
747	PI 357753	Yugoslavia	4.6	9.0	0.7	4	3.5	4.2	6.2
748	PI 381739	India	4.8	9.0	1.4	4	2.3	6.0	6.2
749	PI 381752	India	5.6	7.0	0.0	4	4.7	5.8	6.2
750	PI 525080	Egypt	5.3	9.0	0.0	4	4.2	5.5	6.2
751	PI 537273	Pakistan	5.4	7.0	0.7	4	4.3	5.7	6.2
752	Grif 12336	China	5.1	8.0	0.0	5	3.8	5.2	6.2
753	Grif 16135	France	5.1	8.0	0.0	5	4.2	5.0	6.2
754	Grif 5601	India	5.8	7.0	0.0	5	5.3	5.8	6.2
755	PI 167125	Turkey	5.2	8.0	0.0	5	3.8	5.5	6.2
756	PI 169258	Turkey	5.0	8.0	0.7	5	3.7	5.2	6.2
757	PI 169296	Turkey	4.3	9.0	0.0	5	2.5	4.2	6.2
758	PI 171585	Turkey	4.6	8.0	0.0	5	3.2	4.3	6.2
759	PI 172794	Turkey	5.4	9.0	0.0	5	5.0	5.2	6.2
760	PI 172799	Turkey	5.2	9.0	0.0	5	4.7	4.7	6.2
761	PI 172803	Turkey	4.5	8.0	0.0	5	3.0	4.3	6.2
762	PI 175651	Turkey	5.0	8.0	0.0	5	3.8	5.0	6.2
763	PI 176911	Turkey	4.7	8.0	1.4	5	3.8	4.0	6.2
764	PI 176913	Turkey	4.8	9.0	0.7	5	3.5	4.8	6.2
765	PI 222137	Algeria	5.2	7.0	0.0	5	4.2	5.3	6.2
766	PI 222776	Iran	5.1	9.0	0.7	5	4.0	5.2	6.2
767	PI 229686	Iran	4.5	9.0	1.4	5	2.3	5.0	6.2
768	PI 240532	Iran	4.8	8.0	0.7	5	3.7	4.5	6.2
769	PI 251244	India	5.4	9.0	1.4	5	4.7	5.5	6.2
770	PI 253174	Yugoslavia	5.2	9.0	1.4	5	4.2	5.2	6.2
771	PI 276659	Soviet Union	5.0	9.0	0.7	5	3.5	5.3	6.2
772	PI 277979	Turkey	4.9	7.0	1.4	5	3.5	5.2	6.2
773	PI 277992	Turkey	4.4	9.0	1.4	5	2.7	4.5	6.2
774	PI 278042	Turkey	5.3	8.0	0.7	5	4.0	5.7	6.2
775	PI 319236	Japan	5.2	9.0	2.1	5	4.3	5.2	6.2
776	PI 325248	Soviet Union	4.9	9.0	1.4	5	4.0	4.5	6.2

Appendix1 continued

777	PI 357658	Yugoslavia	5.0	8.0	0.7	5	3.8	5.0	6.2
778	PI 357659	Yugoslavia	4.6	7.0	0.7	5	3.0	4.7	6.2
779	PI 357684	Yugoslavia	5.6	9.0	2.1	5	5.0	5.7	6.2
780	PI 357703	Yugoslavia	5.3	9.0	0.0	5	4.2	5.5	6.2
781	PI 357742	Yugoslavia	4.9	8.0	2.8	5	3.8	4.7	6.2
782	PI 368494	Yugoslavia	4.8	8.0	0.7	5	3.0	5.2	6.2
783	PI 370434	Yugoslavia	4.7	7.0	0.0	5	2.8	5.2	6.2
784	PI 378613	Zaire	4.4	7.0	0.7	5	2.3	4.7	6.2
785	PI 378615	Zaire	4.6	9.0	0.0	5	2.2	5.3	6.2
786	PI 381694	India	5.5	9.0	0.7	5	4.8	5.5	6.2
787	PI 381749	India	5.7	7.0	0.0	5	4.8	6.0	6.2
788	PI 432337	Cyprus	4.7	8.0	1.4	5	3.5	4.5	6.2
789	PI 476324	Soviet Union	5.2	9.0	0.7	5	4.3	5.0	6.2
790	PI 476326	Soviet Union	5.3	8.0	1.4	5	4.7	5.2	6.2
791	PI 487476	Israel	5.4	7.0	0.0	5	4.7	5.3	6.2
792	PI 500348	Zambia	4.8	8.0	2.1	5	3.5	4.8	6.2
793	PI 508445	South Korea	4.7	8.0	0.0	5	3.2	4.8	6.2
794	PI 512349	Spain	3.8	8.0	0.7	5	1.7	3.7	6.2
795	PI 512383	Spain	4.5	8.0	0.7	5	2.3	5.0	6.2
796	PI 512405	Spain	5.1	9.0	0.0	5	4.5	4.5	6.2
797	PI 525089	Egypt	4.6	8.0	0.7	5	3.2	4.5	6.2
798	PI 525095	Egypt	5.0	9.0	0.0	5	3.8	5.0	6.2
799	PI 526233	Zimbabwe	4.2	8.0	0.7	5	2.3	4.2	6.2
800	PI 532722	Zaire	4.1	8.0	1.4	5	1.5	4.5	6.2
801	PI 532723	Zimbabwe	3.9	9.0	2.1	5	1.7	4.0	6.2
802	PI 537467	Spain	5.1	9.0	0.0	5	4.0	5.2	6.2
803	PI 559992	Nigeria	4.5	8.0	0.7	5	2.7	4.7	6.2
804	PI 593352	China	4.7	9.0	0.7	5	3.7	4.3	6.2
805	PI 593380	China	5.1	8.0	0.0	5	4.5	4.7	6.2
806	PI 169247	Turkey	5.1	9.0	0.0	6	4.3	4.7	6.2
807	PI 169261	Turkey	5.2	9.0	0.0	6	4.5	5.0	6.2
808	PI 173669	Turkey	5.0	8.0	0.7	6	4.2	4.7	6.2
809	PI 176497	Turkey	4.9	8.0	0.7	6	4.0	4.7	6.2
810	PI 179880	India	4.5	8.0	0.7	6	3.2	4.2	6.2
811	PI 212209	Greece	5.2	9.0	0.7	6	4.0	5.3	6.2
812	PI 222775	Iran	4.7	8.0	0.7	6	3.5	4.3	6.2
813	PI 254624	Sudan	5.3	9.0	1.4	6	4.5	5.3	6.2
814	PI 269680	Belize	4.7	8.0	1.4	6	3.7	4.3	6.2
815	PI 271982	Somalia	4.4	9.0	1.4	6	3.0	4.2	6.2

Appendix1 continued

816	PI 276657	Russia	5.8	9.0	2.8	6	5.3	5.8	6.2
817	PI 277971	Turkey	5.1	8.0	0.0	6	4.0	5.2	6.2
818	PI 277974	Turkey	4.9	8.0	2.1	6	3.8	4.7	6.2
819	PI 279456	Japan	5.4	8.0	0.7	6	4.8	5.3	6.2
820	PI 357673	Yugoslavia	5.1	7.0	0.0	6	4.2	4.8	6.2
821	PI 357700	Yugoslavia	4.4	7.0	0.0	6	2.7	4.3	6.2
822	PI 357733	Yugoslavia	4.9	7.0	0.0	6	3.5	5.0	6.2
823	PI 357744	Yugoslavia	4.8	7.0	0.0	6	3.5	4.7	6.2
824	PI 357752	Yugoslavia	5.1	8.0	0.7	6	4.0	5.2	6.2
825	PI 368498	Yugoslavia	4.9	8.0	1.4	6	3.8	4.8	6.2
826	PI 381699	India	4.8	8.0	1.4	6	3.7	4.5	6.2
827	PI 381718	India	4.9	7.0	0.7	6	3.7	5.0	6.2
828	PI 381750	India	5.4	8.0	0.7	6	4.7	5.3	6.2
829	PI 470246	Indonesia	5.0	7.0	0.0	6	3.8	5.0	6.2
830	PI 482334	Zimbabwe	5.0	7.0	0.7	6	4.0	4.8	6.2
831	PI 482339	Zimbabwe	4.6	9.0	2.1	6	2.2	5.5	6.2
832	PI 482353	Zimbabwe	4.8	8.0	1.4	6	3.5	4.7	6.2
833	PI 490386	Mali	5.2	9.0	1.4	6	4.0	5.3	6.2
834	PI 500307	Zambia	4.9	9.0	0.0	6	3.3	5.3	6.2
835	PI 505585	Zambia	5.1	9.0	2.1	6	4.0	5.0	6.2
836	PI 507860	Hungary	4.7	9.0	1.4	6	3.3	4.5	6.2
837	PI 508441	South Korea	4.6	9.0	0.7	6	2.8	4.7	6.2
838	PI 508446	South Korea	5.1	7.0	0.0	6	4.3	4.7	6.2
839	PI 512332	China	5.3	8.0	0.7	6	5.0	4.8	6.2
840	PI 512366	Spain	4.5	9.0	1.4	6	3.2	4.2	6.2
841	PI 512371	Spain	5.2	8.0	0.7	6	4.3	5.2	6.2
842	PI 512390	Spain	4.1	9.0	0.0	6	2.2	4.0	6.2
843	PI 512407	Spain	4.4	9.0	0.7	6	2.5	4.5	6.2
844	PI 532809	China	4.6	9.0	0.7	6	3.0	4.5	6.2
845	PI 534588	Syria	5.4	9.0	1.4	6	4.7	5.3	6.2
846	PI 534589	Syria	5.1	9.0	1.4	6	4.3	4.8	6.2
847	PI 537265	Pakistan	4.9	8.0	0.0	6	4.0	4.7	6.2
848	PI 537266	Pakistan	4.3	8.0	0.7	6	2.2	4.5	6.2
849	PI 559996	Nigeria	4.8	9.0	0.0	6	2.3	5.8	6.2
850	PI 560002	Nigeria	4.6	8.0	0.0	6	3.0	4.7	6.2
851	PI 560013	Nigeria	4.6	8.0	1.4	6	3.3	4.3	6.2
852	PI 593360	China	4.7	8.0	0.7	6	3.0	4.8	6.2
853	PI 593363	China	5.0	9.0	2.1	6	3.7	5.2	6.2
854	PI 601307	United States	4.7	8.0	0.7	6	3.3	4.7	6.2

Appendix1 continued

855	PI 601662	United States	5.0	9.0	0.0	6	3.8	5.0	6.2
856	PI 612463	South Korea	4.6	8.0	0.7	6	3.0	4.7	6.2
857	PI 612466	South Korea	4.6	9.0	1.4	6	3.0	4.7	6.2
858	PI 177331	Syria	4.5	9.0	0.0	4	3.4	3.8	6.2
859	PI 357705	Yugoslavia	6.0	9.0	1.4	5	5.5	6.7	6.2
860	PI 357743	Yugoslavia	5.0	8.0	2.1	5	3.8	4.8	6.2
861	PI 368506	Yugoslavia	5.3	9.0	1.4	5	4.0	5.3	6.2
862	PI 494821	Zambia	5.0	8.0	0.7	5	3.7	5.3	6.2
863	PI 179243	Turkey	4.5	8.0	0.7	3	3.0	4.2	6.2
864	PI 278022	Turkey	4.6	7.0	1.4	3	2.5	5.1	6.2
865	PI 277990	Turkey	5.2	9.0	0.0	4	4.2	5.2	6.2
866	PI 500317	Zambia	4.2	8.0	2.8	4	2.7	3.7	6.2
867	PI 542122	Botswana	5.3	7.0	.	2	4.5	5.0	6.3
868	PI 174101	Turkey	4.2	7.0	.	3	2.3	4.0	6.3
869	PI 181742	Lebanon	6.0	8.0	0.0	3	5.3	6.5	6.3
870	PI 357681	Yugoslavia	5.3	7.0	0.0	3	4.5	5.0	6.3
871	PI 542115	Botswana	5.6	7.0	0.0	3	5.0	5.5	6.3
872	PI 169244	Turkey	4.6	9.0	0.0	4	3.8	3.8	6.3
873	PI 176916	Turkey	5.8	9.0	1.4	4	5.3	6.0	6.3
874	PI 482262	Zimbabwe	4.4	7.0	0.7	4	1.8	5.3	6.3
875	PI 534598	Syria	5.1	8.0	.	4	3.8	5.3	6.3
876	PI 593388	China	4.8	9.0	.	4	3.0	5.3	6.3
877	PI 277986	Turkey	5.2	8.0	0.7	5	4.0	5.3	6.3
878	NC Giant	United States	4.6	7.0	0.0	2	3.8	4.0	6.3
879	GeorgiaRttlsnk2	United States	4.1	7.0	0.7	3	3.0	4.0	6.3
880	PI 269679	Belize	4.6	9.0	0.0	3	3.0	4.3	6.3
881	PI 635592	United States	5.6	8.0	.	3	5.5	6.0	6.3
882	PI 165523	India	4.1	8.0	0.0	4	2.0	3.8	6.3
883	PI 176914	Turkey	5.2	9.0	1.4	4	3.8	5.3	6.3
884	PI 179236	Turkey	5.0	9.0	0.0	4	4.3	4.3	6.3
885	PI 183300	India	4.7	9.0	0.0	4	2.0	5.7	6.3
886	PI 217522	Pakistan	5.6	8.0	0.0	4	4.5	5.8	6.3
887	PI 217939	Pakistan	5.6	7.0	0.0	4	5.3	5.2	6.3
888	PI 240533	Iran	4.9	8.0	0.0	4	3.2	5.2	6.3
889	PI 357667	Yugoslavia	4.9	9.0	0.0	4	3.3	5.2	6.3
890	PI 368529	Yugoslavia	5.5	7.0	0.0	4	5.0	5.2	6.3
891	PI 370432	Yugoslavia	5.4	8.0	0.0	4	4.8	5.0	6.3
892	PI 379237	Yugoslavia	5.4	8.0	1.4	4	4.3	5.5	6.3
893	PI 415095	Honduras	4.9	8.0	0.0	4	3.7	4.7	6.3

Appendix1 continued

894	PI 512364	Spain	5.3	8.0	1.4	4	4.2	5.5	6.3
895	PI 652554	India	4.8	9.0	0.0	4	3.0	5.0	6.3
896	Grif 15898	United States	5.2	7.0	0.0	5	4.2	5.2	6.3
897	Grif 1734	China	4.7	9.0	0.0	5	2.7	5.2	6.3
898	PI 164685	India	5.4	8.0	1.4	5	4.5	5.3	6.3
899	PI 167026	Turkey	5.2	9.0	2.1	5	4.2	5.2	6.3
900	PI 169262	Turkey	4.9	8.0	0.7	5	3.3	5.2	6.3
901	PI 169292	Turkey	4.9	9.0	0.0	5	3.8	4.7	6.3
902	PI 176498	Turkey	4.8	8.0	0.7	5	3.2	4.8	6.3
903	PI 178872	Turkey	4.7	8.0	0.0	5	2.8	5.0	6.3
904	PI 179234	Turkey	4.8	7.0	0.0	5	3.7	4.3	6.3
905	PI 189316	Nigeria	5.7	9.0	0.7	5	4.8	6.0	6.3
906	PI 207472	Afghanistan	5.9	9.0	0.0	5	5.2	6.3	6.3
907	PI 211013	Afghanistan	5.6	9.0	0.0	5	5.0	5.5	6.3
908	PI 220778	Afghanistan	5.1	7.0	1.4	5	3.7	5.3	6.3
909	PI 222778	Iran	5.1	9.0	0.0	5	3.7	5.3	6.3
910	PI 226445	Israel	5.2	9.0	0.0	5	4.0	5.2	6.3
911	PI 242906	Afghanistan	5.8	9.0	0.7	5	5.0	6.0	6.3
912	PI 274794	Pakistan	5.6	9.0	0.7	5	4.8	5.7	6.3
913	PI 276658	Soviet Union	4.6	9.0	0.0	5	3.0	4.5	6.3
914	PI 278015	Turkey	5.2	9.0	0.0	5	4.2	5.0	6.3
915	PI 278030	Turkey	5.3	9.0	0.7	5	4.5	5.2	6.3
916	PI 278034	Turkey	5.0	7.0	0.7	5	4.0	4.7	6.3
917	PI 278062	Turkey	5.0	8.0	0.7	5	3.5	5.2	6.3
918	PI 288232	Egypt	5.2	9.0	0.0	5	3.7	5.7	6.3
919	PI 306782	Nigeria	4.9	9.0	0.0	5	3.2	5.3	6.3
920	PI 357672	Yugoslavia	5.5	9.0	0.0	5	4.7	5.5	6.3
921	PI 357685	Yugoslavia	4.9	9.0	2.8	5	3.5	5.0	6.3
922	PI 357693	Yugoslavia	4.5	8.0	0.0	5	3.3	3.8	6.3
923	PI 357698	Yugoslavia	5.2	8.0	0.0	5	4.2	5.2	6.3
924	PI 370422	Yugoslavia	4.9	8.0	0.7	5	3.5	4.8	6.3
925	PI 381700	India	5.5	9.0	2.8	5	3.8	6.3	6.3
926	PI 431579	India	5.1	7.0	0.0	5	4.0	5.0	6.3
927	PI 435991	China	5.4	9.0	1.4	5	4.7	5.3	6.3
928	PI 482377	Zimbabwe	4.9	9.0	1.4	5	3.5	4.8	6.3
929	PI 494527	Nigeria	4.9	8.0	0.7	5	4.0	4.5	6.3
930	PI 500353	Zambia	4.3	8.0	0.7	5	2.2	4.5	6.3
931	PI 507863	Hungary	4.8	9.0	0.0	5	3.3	4.8	6.3
932	PI 507868	Hungary	4.4	9.0	0.0	5	2.2	4.8	6.3

Appendix1 continued

933	PI 525082	Egypt	4.8	8.0	1.4	5	3.5	4.7	6.3
934	PI 532816	China	4.9	8.0	1.4	5	3.2	5.3	6.3
935	PI 532817	China	4.9	9.0	0.0	5	3.5	5.0	6.3
936	PI 535947	Cameroon	4.5	9.0	0.0	5	3.0	4.2	6.3
937	PI 537271	Pakistan	4.9	9.0	2.1	5	3.7	4.7	6.3
938	PI 537471	Spain	5.2	7.0	0.7	5	4.3	5.0	6.3
939	PI 543211	Bolivia	4.9	9.0	0.7	5	3.8	4.7	6.3
940	PI 543212	Bolivia	4.7	8.0	1.4	5	3.0	4.8	6.3
941	PI 561122	China	5.2	8.0	0.7	5	4.0	5.2	6.3
942	PI 593375	China	5.1	9.0	0.0	5	4.3	4.7	6.3
943	PI 593384	China	4.6	7.0	0.0	5	2.3	5.2	6.3
944	PI 608047	United States	4.6	9.0	0.0	5	3.0	4.3	6.3
945	PI 612472	South Korea	4.9	8.0	0.7	5	3.0	5.3	6.3
946	PI 635612	United States	4.9	8.0	0.0	5	3.7	4.8	6.3
947	Sangria	United States	4.9	8.0	0.7	5	3.0	5.5	6.3
948	Blacklee	United States	4.3	9.0	0.7	6	2.3	4.3	6.3
949	DMR-111	United States	5.2	8.0	0.7	6	4.0	5.2	6.3
950	Grif 1730	China	4.9	8.0	0.7	6	3.7	4.8	6.3
951	PI 166993	Turkey	4.9	9.0	0.0	6	3.8	4.5	6.3
952	PI 169260	Turkey	5.1	8.0	0.7	6	4.3	4.5	6.3
953	PI 175664	Turkey	5.1	9.0	0.7	6	3.7	5.2	6.3
954	PI 177324	Turkey	4.8	9.0	0.0	6	3.5	4.5	6.3
955	PI 181937	Syria	5.7	9.0	1.4	6	4.7	6.0	6.3
956	PI 249559	Thailand	5.0	8.0	1.4	6	4.0	4.7	6.3
957	PI 254736	Senegal	4.4	8.0	0.7	6	3.0	4.0	6.3
958	PI 255662	Afghanistan	4.7	9.0	2.1	6	2.8	4.8	6.3
959	PI 269466	Pakistan	4.9	9.0	0.7	6	3.7	4.8	6.3
960	PI 271752	Ghana	4.7	8.0	0.0	6	3.2	4.7	6.3
961	PI 275628	Pakistan	4.1	9.0	0.0	6	2.7	3.3	6.3
962	PI 277970	Turkey	5.9	9.0	1.4	6	5.5	5.8	6.3
963	PI 277997	Turkey	5.1	9.0	2.1	6	2.8	6.0	6.3
964	PI 278038	Turkey	4.9	9.0	0.0	6	3.7	4.8	6.3
965	PI 290855	United States	5.1	9.0	1.4	6	3.8	5.2	6.3
966	PI 357676	Yugoslavia	5.2	8.0	0.0	6	4.2	5.2	6.3
967	PI 357720	Yugoslavia	4.9	8.0	0.7	6	3.5	4.8	6.3
968	PI 357741	Yugoslavia	5.4	9.0	0.0	6	4.7	5.2	6.3
969	PI 368518	Yugoslavia	5.2	8.0	0.7	6	4.2	5.2	6.3
970	PI 379252	Yugoslavia	4.8	9.0	1.4	6	3.0	5.2	6.3
971	PI 379257	Yugoslavia	4.9	8.0	0.7	6	3.8	4.7	6.3

Appendix1 continued

972	PI 381696	India	5.0	9.0	0.7	6	4.0	4.7	6.3
973	PI 381715	India	4.9	9.0	2.8	6	3.5	4.8	6.3
974	PI 381755	India	5.0	8.0	0.7	6	3.5	5.2	6.3
975	PI 388021	India	4.4	9.0	1.4	6	2.8	4.0	6.3
976	PI 482351	Zimbabwe	5.0	9.0	0.7	6	3.8	4.8	6.3
977	PI 482360	Zimbabwe	5.2	9.0	1.4	6	4.3	5.0	6.3
978	PI 482362	Zimbabwe	4.2	8.0	0.7	6	1.7	4.7	6.3
979	PI 482380	Zimbabwe	4.5	8.0	0.7	6	2.2	5.0	6.3
980	PI 494815	Zambia	4.7	9.0	1.4	6	2.7	5.0	6.3
981	PI 505589	Zambia	4.6	8.0	0.0	6	2.8	4.7	6.3
982	PI 512342	Spain	4.6	9.0	0.0	6	2.8	4.5	6.3
983	PI 512347	Spain	4.6	8.0	0.7	6	3.0	4.3	6.3
984	PI 512350	Spain	5.0	9.0	1.4	6	4.0	4.7	6.3
985	PI 512354	Spain	4.9	9.0	0.7	6	3.0	5.3	6.3
986	PI 512376	Spain	4.8	9.0	1.4	6	3.0	5.2	6.3
987	PI 512396	Spain	5.8	9.0	1.4	6	5.2	5.8	6.3
988	PI 512833	Spain	5.1	8.0	0.7	6	3.8	5.2	6.3
989	PI 525093	Egypt	4.9	9.0	0.0	6	4.2	4.2	6.3
990	PI 532810	China	4.8	7.0	0.7	6	3.5	4.5	6.3
991	PI 532814	China	4.9	7.0	0.0	6	3.5	5.0	6.3
992	PI 534530	Syria	5.1	9.0	0.0	6	4.2	4.7	6.3
993	PI 537299	Uzbekistan	4.8	8.0	0.0	6	3.3	4.7	6.3
994	PI 560001	Nigeria	4.5	9.0	0.7	6	2.5	4.7	6.3
995	PI 593377	China	4.7	8.0	2.1	6	2.8	5.0	6.3
996	PI 612465	South Korea	4.5	8.0	0.7	6	2.5	4.7	6.3
997	PI 612474	South Korea	5.3	8.0	1.4	6	4.3	5.2	6.3
998	PI 629109	United States	4.6	9.0	0.0	6	3.2	4.3	6.3
999	Navajo Sweet	United States	5.4	9.0	0.0	3	4.8	5.5	6.4
1000	PI 632753	United States	4.9	7.0	0.7	5	4.2	4.8	6.4
1001	PI 635606	United States	5.3	8.0	0.7	5	4.0	5.8	6.4
1002	PI 635607	United States	4.6	8.0	0.7	5	3.5	4.7	6.4
1003	PI 658680	China	4.8	8.0	2.8	5	3.7	5.0	6.4
1004	Perola	United States	4.6	8.0	1.4	5	3.5	4.5	6.4
1005	Mountain Hoosier	United States	6.8	7.0	.	2	7.0	7.0	6.5
1006	PI 184800	Nigeria	6.7	9.0	0.0	2	6.5	7.0	6.5
1007	PI 368516	Yugoslavia	5.2	7.0	0.0	2	3.5	5.5	6.5
1008	PI 542120	Botswana	6.7	8.0	.	2	7.0	6.5	6.5
1009	Tendergold	United States	6.0	7.0	.	2	4.5	7.0	6.5
1010	Tom Watson	United States	6.8	7.0	.	2	7.0	7.0	6.5

Appendix1 continued

1011	PI 279461	Japan	6.0	9.0	.	3	5.5	6.0	6.5
1012	PI 500324	Zambia	6.0	7.0	.	3	5.0	6.5	6.5
1013	Chubby Gray	United States	4.3	7.0	0.0	4	2.5	3.8	6.5
1014	Grif 5597	India	4.8	8.0	2.1	4	3.2	4.7	6.5
1015	PI 169265	Turkey	4.7	9.0	0.7	4	2.3	5.3	6.5
1016	PI 169299	Turkey	4.0	7.0	0.0	4	1.8	3.8	6.5
1017	PI 174103	Turkey	6.4	9.0	0.0	4	6.5	6.3	6.5
1018	PI 176496	Turkey	4.5	9.0	0.7	4	3.0	4.0	6.5
1019	PI 179242	Iraq	4.5	8.0	0.7	4	1.8	5.3	6.5
1020	PI 183673	Turkey	5.7	9.0	0.0	4	4.5	6.0	6.5
1021	PI 195771	Guatemala	5.0	8.0	1.4	4	3.8	4.8	6.5
1022	PI 270545	Sudan	5.1	8.0	0.0	4	4.0	4.8	6.5
1023	PI 278016	Turkey	4.7	9.0	0.0	4	3.0	4.5	6.5
1024	PI 299563	South Africa	4.8	8.0	2.1	4	3.3	4.8	6.5
1025	PI 319237	Japan	4.4	9.0	0.7	4	2.8	4.0	6.5
1026	PI 368526	Yugoslavia	5.4	8.0	0.7	4	4.7	5.0	6.5
1027	PI 370015	India	5.7	9.0	0.0	4	4.8	5.7	6.5
1028	PI 381704	India	4.0	8.0	0.0	4	1.5	4.0	6.5
1029	PI 441722	Brazil	4.8	9.0	0.0	4	2.5	5.5	6.5
1030	PI 490376	Mali	4.9	9.0	0.7	4	3.2	5.0	6.5
1031	PI 538888	Russia	5.1	8.0	0.7	4	4.7	4.0	6.5
1032	PI 560012	Nigeria	4.4	8.0	0.0	4	2.0	4.7	6.5
1033	PI 612471	South Korea	5.4	8.0	0.0	4	4.7	5.0	6.5
1034	PI 635615	United States	4.3	8.0	0.7	4	3.7	4.0	6.5
1035	Grif 5599	India	5.3	9.0	1.4	5	4.0	5.3	6.5
1036	PI 164998	Turkey	5.8	9.0	0.7	5	5.0	6.0	6.5
1037	PI 167045	Turkey	5.2	9.0	0.0	5	4.2	4.8	6.5
1038	PI 167126	Turkey	5.5	8.0	0.7	5	4.3	5.7	6.5
1039	PI 169295	Turkey	6.2	9.0	0.0	5	5.8	6.3	6.5
1040	PI 172792	Turkey	5.2	9.0	0.7	5	4.5	4.7	6.5
1041	PI 172800	Turkey	5.2	8.0	0.7	5	4.3	4.8	6.5
1042	PI 173668	Turkey	4.8	9.0	0.0	5	3.0	4.8	6.5
1043	PI 175650	Turkey	5.2	9.0	0.0	5	3.3	5.8	6.5
1044	PI 176485	Turkey	4.5	8.0	0.0	5	3.2	3.8	6.5
1045	PI 176905	Turkey	5.3	9.0	0.7	5	4.0	5.3	6.5
1046	PI 178877	Turkey	5.8	9.0	0.7	5	4.7	6.2	6.5
1047	PI 195928	Ethiopia	4.6	9.0	0.7	5	2.5	4.8	6.5
1048	PI 212287	Afghanistan	4.9	9.0	0.0	5	3.7	4.7	6.5
1049	PI 212289	Afghanistan	5.3	9.0	2.1	5	4.2	5.3	6.5

Appendix1 continued

1050	PI 217938	Pakistan	5.0	9.0	0.0	5	3.8	4.7	6.5
1051	PI 228342	Iran	6.0	9.0	0.0	5	5.5	6.0	6.5
1052	PI 266025	Venezuela	4.8	8.0	0.0	5	3.8	4.2	6.5
1053	PI 277981	Turkey	5.4	9.0	0.0	5	4.3	5.3	6.5
1054	PI 314655	Soviet Union	6.1	9.0	0.0	5	4.8	7.0	6.5
1055	PI 345545	Ukraine	4.9	9.0	0.0	5	3.0	5.2	6.5
1056	PI 357656	Yugoslavia	5.2	8.0	0.0	5	4.2	4.8	6.5
1057	PI 357704	Yugoslavia	5.4	8.0	0.0	5	4.7	5.0	6.5
1058	PI 357716	Yugoslavia	5.2	8.0	1.4	5	3.5	5.7	6.5
1059	PI 357717	Yugoslavia	5.1	9.0	0.0	5	3.5	5.2	6.5
1060	PI 357732	Yugoslavia	5.4	8.0	0.7	5	4.8	5.0	6.5
1061	PI 368493	Yugoslavia	4.7	9.0	0.0	5	3.3	4.3	6.5
1062	PI 368495	Yugoslavia	5.2	8.0	0.7	5	3.8	5.3	6.5
1063	PI 368499	Yugoslavia	5.0	7.0	0.0	5	4.0	4.5	6.5
1064	PI 370424	Yugoslavia	5.5	9.0	1.4	5	4.3	5.7	6.5
1065	PI 370428	Yugoslavia	5.1	9.0	0.7	5	3.5	5.3	6.5
1066	PI 379222	Yugoslavia	5.1	8.0	0.0	5	3.5	5.2	6.5
1067	PI 379226	Yugoslavia	5.4	9.0	2.1	5	4.3	5.5	6.5
1068	PI 379246	Yugoslavia	4.7	9.0	0.7	5	2.3	5.3	6.5
1069	PI 381697	India	5.8	9.0	0.7	5	4.8	6.2	6.5
1070	PI 470249	Indonesia	4.7	9.0	0.0	5	2.8	4.8	6.5
1071	PI 476328	Soviet Union	5.3	8.0	0.7	5	4.5	4.8	6.5
1072	PI 482248	Zimbabwe	4.8	7.0	1.4	5	2.5	5.5	6.5
1073	PI 482341	Zimbabwe	4.8	9.0	0.7	5	2.3	5.7	6.5
1074	PI 500333	Zambia	5.3	9.0	2.8	5	3.7	5.8	6.5
1075	PI 507869	Hungary	5.2	9.0	0.0	5	3.7	5.3	6.5
1076	PI 512361	Spain	4.8	9.0	0.7	5	2.5	5.3	6.5
1077	PI 512368	Spain	5.2	8.0	0.0	5	4.2	5.0	6.5
1078	PI 518609	Russia	5.0	8.0	1.4	5	3.2	5.3	6.5
1079	PI 535948	Cameroon	5.2	9.0	2.1	5	3.3	5.7	6.5
1080	PI 560007	Nigeria	5.0	9.0	2.1	5	2.8	5.7	6.5
1081	PI 593358	China	5.2	9.0	2.1	5	4.0	5.2	6.5
1082	Long Crimson	United States	5.1	8.0	0.7	6	3.8	5.0	6.5
1083	PI 165002	Turkey	5.7	9.0	0.0	6	4.8	5.8	6.5
1084	PI 172790	Turkey	5.1	9.0	0.7	6	4.0	4.7	6.5
1085	PI 174098	Turkey	5.2	9.0	0.0	6	3.7	5.3	6.5
1086	PI 176907	Turkey	4.8	8.0	0.7	6	3.2	4.8	6.5
1087	PI 176915	Turkey	5.2	9.0	1.4	6	4.7	4.5	6.5
1088	PI 179661	India	5.2	9.0	1.4	6	4.2	4.8	6.5

Appendix1 continued

1089	PI 179876	India	5.2	9.0	0.0	6	4.3	4.8	6.5
1090	PI 180276	India	5.4	9.0	0.7	6	4.7	5.2	6.5
1091	PI 180278	India	5.1	9.0	0.7	6	3.8	4.8	6.5
1092	PI 183218	Egypt	5.3	9.0	2.1	6	4.2	5.2	6.5
1093	PI 220779	Afghanistan	5.1	9.0	0.7	6	3.8	5.0	6.5
1094	PI 254740	Senegal	4.7	8.0	0.7	6	2.8	4.7	6.5
1095	PI 254741	Senegal	5.1	8.0	0.0	6	4.0	4.7	6.5
1096	PI 270140	India	5.6	9.0	1.4	6	5.0	5.2	6.5
1097	PI 275632	India	5.1	8.0	0.7	6	4.3	4.5	6.5
1098	PI 278001	Turkey	5.0	9.0	0.0	6	3.8	4.7	6.5
1099	PI 278003	Turkey	5.1	8.0	0.0	6	3.5	5.2	6.5
1100	PI 278005	Turkey	4.9	8.0	0.7	6	3.5	4.8	6.5
1101	PI 278046	Turkey	5.2	9.0	0.7	6	3.5	5.5	6.5
1102	PI 278051	Turkey	5.0	8.0	0.7	6	3.3	5.2	6.5
1103	PI 288317	India	5.4	9.0	0.7	6	4.2	5.5	6.5
1104	PI 357696	Yugoslavia	4.8	9.0	1.4	6	3.0	5.0	6.5
1105	PI 357706	Yugoslavia	5.6	9.0	0.7	6	4.3	6.0	6.5
1106	PI 357719	Yugoslavia	5.2	9.0	0.0	6	4.0	5.0	6.5
1107	PI 379223	Yugoslavia	5.2	7.0	0.0	6	3.8	5.3	6.5
1108	PI 379230	Yugoslavia	4.6	8.0	1.4	6	3.2	4.0	6.5
1109	PI 381722	India	5.1	8.0	0.7	6	4.2	4.7	6.5
1110	PI 392291	Kenya	4.6	9.0	0.0	6	3.2	4.0	6.5
1111	PI 457916	Brazil	4.8	9.0	2.8	6	3.3	4.7	6.5
1112	PI 482352	Zimbabwe	4.4	9.0	0.7	6	2.7	4.0	6.5
1113	PI 490375	Mali	5.2	8.0	0.7	6	4.0	5.0	6.5
1114	PI 494819	Zambia	4.9	9.0	1.4	6	3.3	4.8	6.5
1115	PI 502316	Uzbekistan	5.1	9.0	0.0	6	3.3	5.3	6.5
1116	PI 505594	Zambia	4.8	9.0	2.1	6	2.8	5.2	6.5
1117	PI 506439	Moldova	4.4	9.0	2.1	6	2.3	4.3	6.5
1118	PI 512352	Spain	5.2	9.0	2.1	6	3.7	5.5	6.5
1119	PI 512379	Spain	4.8	9.0	0.0	6	3.2	4.8	6.5
1120	PI 512394	Spain	5.2	8.0	0.7	6	4.0	5.2	6.5
1121	PI 512398	Spain	5.1	9.0	0.0	6	4.0	4.8	6.5
1122	PI 525094	Egypt	5.1	8.0	0.7	6	3.5	5.2	6.5
1123	PI 536446	Maldives	4.8	9.0	0.7	6	3.2	4.8	6.5
1124	PI 536448	Maldives	4.8	9.0	0.0	6	3.2	4.7	6.5
1125	PI 537275	Pakistan	5.2	8.0	0.0	6	4.2	5.0	6.5
1126	PI 559997	Nigeria	4.4	9.0	0.0	6	2.2	4.5	6.5
1127	PI 593366	China	5.3	9.0	0.7	6	4.3	5.0	6.5

Appendix1 continued

1128	PI 593369	China	4.7	8.0	0.0	6	2.5	5.0	6.5
1129	PI 593378	China	5.2	8.0	0.0	6	4.3	4.8	6.5
1130	PI 593387	China	5.6	9.0	0.7	6	4.7	5.7	6.5
1131	PI 601289	United States	5.1	8.0	0.7	6	4.2	4.7	6.5
1132	PI 612461	South Korea	5.2	8.0	0.7	6	4.0	5.2	6.5
1133	PI 629106	United States	5.1	8.0	1.4	6	3.8	5.0	6.5
1134	PI 632754	Bulgaria	5.3	8.0	0.0	6	3.8	5.5	6.5
1135	Sugarlee	United States	5.3	8.0	0.7	6	4.3	5.2	6.5
1136	Crimson Sweet	United States	5.7	8.0	0.7	4	4.7	6.0	6.6
1137	Minilee	United States	5.3	9.0	0.7	5	4.2	5.5	6.6
1138	PI 331106	Uruguay	5.5	9.0	0.7	5	4.7	5.3	6.6
1139	PI 612475	South Korea	5.2	8.0	0.7	5	3.8	5.5	6.6
1140	PI 632752	United States	4.9	8.0	0.7	5	4.0	4.5	6.6
1141	PI 344066	Turkey	5.3	6.0	0.0	2	3.3	6.0	6.7
1142	Congo	United States	6.5	9.0	2.1	3	6.3	6.3	6.7
1143	PI 525086	Egypt	6.2	9.0	0.0	3	5.3	6.7	6.7
1144	PI 169235	Turkey	5.4	9.0	0.0	4	4.2	5.3	6.7
1145	PI 172797	Turkey	4.8	8.0	0.7	4	2.8	4.8	6.7
1146	PI 176495	Turkey	5.2	8.0	0.7	4	3.7	5.2	6.7
1147	PI 228238	Israel	5.1	9.0	1.4	4	3.2	5.3	6.7
1148	PI 277983	Turkey	5.6	7.0	0.7	4	5.0	5.0	6.7
1149	PI 368523	Yugoslavia	5.4	8.0	0.7	4	3.8	5.8	6.7
1150	PI 370018	India	5.1	9.0	2.8	4	3.7	4.8	6.7
1151	PI 379231	Yugoslavia	4.8	7.0	1.4	4	3.3	4.3	6.7
1152	New Winter	United States	5.0	9.0	0.0	5	3.5	4.8	6.7
1153	PI 164977	Turkey	6.1	9.0	0.7	5	5.2	6.3	6.7
1154	PI 169257	Turkey	5.1	9.0	0.0	5	3.7	4.8	6.7
1155	PI 173888	India	5.5	8.0	0.0	5	4.3	5.5	6.7
1156	PI 175102	India	5.1	8.0	0.7	5	4.0	4.7	6.7
1157	PI 176906	Turkey	4.7	9.0	0.0	5	3.3	4.2	6.7
1158	PI 179238	Turkey	4.2	8.0	0.0	5	2.0	4.0	6.7
1159	PI 179241	Iraq	5.2	8.0	0.0	5	3.8	5.0	6.7
1160	PI 179885	India	5.6	9.0	1.4	5	4.5	5.7	6.7
1161	PI 181741	Lebanon	5.3	9.0	1.4	5	4.0	5.3	6.7
1162	PI 192937	China	5.2	8.0	0.7	5	3.8	5.0	6.7
1163	PI 211850	Iran	4.8	9.0	0.0	5	3.5	4.3	6.7
1164	PI 221430	Iran	5.2	9.0	0.0	5	3.8	5.2	6.7
1165	PI 226506	Iran	5.9	9.0	1.4	5	5.0	6.2	6.7
1166	PI 269676	Belize	5.2	9.0	0.0	5	3.5	5.3	6.7

Appendix1 continued

1167	PI 270145	Greece	5.7	9.0	0.7	5	5.0	5.5	6.7
1168	PI 271467	India	5.6	7.0	0.0	5	4.7	5.5	6.7
1169	PI 271749	Afghanistan	5.4	8.0	0.7	5	4.7	5.0	6.7
1170	PI 277972	Turkey	5.4	9.0	0.0	5	4.0	5.7	6.7
1171	PI 277985	Turkey	4.8	9.0	0.7	5	2.8	5.0	6.7
1172	PI 277987	Turkey	4.6	9.0	2.1	5	2.8	4.2	6.7
1173	PI 278029	Turkey	5.6	9.0	2.1	5	4.7	5.5	6.7
1174	PI 368521	Yugoslavia	4.7	9.0	2.1	5	3.5	4.0	6.7
1175	PI 512382	Spain	4.7	8.0	0.0	5	2.5	5.0	6.7
1176	PI 512392	Spain	5.1	9.0	0.0	5	3.7	5.0	6.7
1177	PI 518608	Russia	5.6	9.0	0.7	5	4.3	5.8	6.7
1178	PI 537274	Pakistan	5.4	9.0	0.0	5	4.2	5.3	6.7
1179	PI 593346	China	5.3	7.0	0.0	5	3.8	5.5	6.7
1180	PI 612467	South Korea	4.8	8.0	0.0	5	3.3	4.5	6.7
1181	Mickylee	United States	5.0	9.0	2.1	6	3.2	5.2	6.7
1182	PI 165451	Mexico	5.7	8.0	0.0	6	5.0	5.3	6.7
1183	PI 171584	Turkey	5.2	9.0	0.0	6	4.5	4.3	6.7
1184	PI 172793	Turkey	5.4	9.0	1.4	6	4.3	5.2	6.7
1185	PI 175663	Turkey	4.8	9.0	0.0	6	3.3	4.5	6.7
1186	PI 176492	Turkey	5.6	9.0	0.0	6	4.8	5.3	6.7
1187	PI 177323	Turkey	4.7	9.0	0.7	6	2.7	4.7	6.7
1188	PI 178871	Turkey	5.3	9.0	0.0	6	4.3	5.0	6.7
1189	PI 179660	India	5.6	9.0	0.0	6	4.5	5.7	6.7
1190	PI 179877	India	5.1	9.0	2.1	6	4.0	4.7	6.7
1191	PI 183126	India	5.6	9.0	0.7	6	4.5	5.7	6.7
1192	PI 195927	Ethiopia	4.9	9.0	0.0	6	3.3	4.8	6.7
1193	PI 269365	Afghanistan	5.3	8.0	0.7	6	4.0	5.2	6.7
1194	PI 270307	Philippines	5.3	9.0	0.7	6	4.3	5.0	6.7
1195	PI 270547	Ghana	5.0	9.0	0.0	6	3.8	4.5	6.7
1196	PI 270550	Ghana	5.2	9.0	1.4	6	4.0	4.8	6.7
1197	PI 278047	Turkey	5.6	9.0	0.0	6	4.7	5.3	6.7
1198	PI 278049	Turkey	5.5	9.0	0.0	6	4.8	5.0	6.7
1199	PI 278056	Turkey	5.4	8.0	1.4	6	4.2	5.3	6.7
1200	PI 307748	Philippines	5.2	8.0	0.7	6	3.8	5.2	6.7
1201	PI 357689	Yugoslavia	4.7	9.0	0.7	6	3.0	4.3	6.7
1202	PI 357721	Yugoslavia	5.2	9.0	2.1	6	4.3	4.5	6.7
1203	PI 368520	Yugoslavia	5.1	9.0	0.7	6	4.2	4.5	6.7
1204	PI 370429	Yugoslavia	5.1	9.0	0.7	6	3.8	4.7	6.7
1205	PI 370431	Yugoslavia	4.9	8.0	0.0	6	3.2	5.0	6.7

Appendix1 continued

1206	PI 379247	Yugoslavia	5.2	8.0	0.7	6	3.7	5.2	6.7
1207	PI 381701	India	5.2	9.0	0.0	6	3.5	5.3	6.7
1208	PI 381707	India	5.4	8.0	0.7	6	4.7	5.0	6.7
1209	PI 381712	India	5.4	9.0	0.0	6	4.0	5.7	6.7
1210	PI 381721	India	5.2	8.0	0.0	6	3.5	5.5	6.7
1211	PI 442826	Brazil	5.2	9.0	1.4	6	3.7	5.3	6.7
1212	PI 482263	Zimbabwe	4.8	9.0	1.4	6	2.8	5.0	6.7
1213	PI 494528	Nigeria	4.7	9.0	1.4	6	3.2	4.3	6.7
1214	PI 512355	Spain	5.3	9.0	2.8	6	4.2	5.2	6.7
1215	PI 512365	Spain	4.7	9.0	0.0	6	2.3	5.0	6.7
1216	PI 512384	Spain	5.2	9.0	0.7	6	3.8	5.0	6.7
1217	PI 512403	Spain	4.9	9.0	0.0	6	3.3	4.8	6.7
1218	PI 525099	Italy	5.1	8.0	0.7	6	4.2	4.5	6.7
1219	PI 534584	Syria	6.2	9.0	2.8	6	5.7	6.3	6.7
1220	PI 534587	Syria	4.9	8.0	0.7	6	3.3	4.7	6.7
1221	PI 536450	Maldives	4.8	9.0	2.8	6	2.8	4.8	6.7
1222	PI 543210	Bolivia	5.6	8.0	0.0	6	4.8	5.2	6.7
1223	PI 593351	China	4.6	9.0	0.7	6	2.3	4.7	6.7
1224	PI 593357	China	5.0	9.0	0.0	6	3.5	4.8	6.7
1225	PI 593364	China	5.3	8.0	0.7	6	4.0	5.2	6.7
1226	PI 593386	China	4.8	9.0	0.0	6	2.8	5.0	6.7
1227	PI 600896	United States	4.9	8.0	0.0	6	3.2	5.0	6.7
1228	PI 601182	United States	5.1	8.0	0.7	6	3.8	4.8	6.7
1229	PI 601221	United States	5.2	9.0	1.4	6	3.3	5.7	6.7
1230	PI 601228	United States	5.3	8.0	0.0	6	4.0	5.2	6.7
1231	PI 612145	United States	4.9	8.0	0.7	6	3.0	5.2	6.7
1232	PI 357730	Yugoslavia	5.5	9.0	0.0	4	4.2	5.7	6.7
1233	PI 212983	India	4.7	8.0	0.7	3	3.5	5.0	6.8
1234	PI 227204	Japan	5.1	9.0	0.7	3	2.3	6.3	6.8
1235	PI 368510	Yugoslavia	5.5	8.0	0.7	3	4.5	5.3	6.8
1236	PI 508442	South Korea	4.4	9.0	0.0	3	2.3	4.3	6.8
1237	PI 164992	Turkey	4.9	8.0	0.7	4	3.0	5.0	6.8
1238	PI 169252	Turkey	4.8	9.0	1.4	4	3.5	4.3	6.8
1239	PI 357665	Yugoslavia	5.3	9.0	0.0	4	4.5	4.8	6.8
1240	PI 357724	Yugoslavia	5.3	9.0	0.7	4	4.3	5.0	6.8
1241	PI 169274	Turkey	5.3	8.0	0.7	5	4.0	5.0	6.8
1242	Louisiana Sweet	United States	4.8	7.0	0.0	3	3.5	4.8	6.8
1243	Grif 1729	China	4.9	9.0	0.7	4	3.0	5.6	6.8
1244	PI 276444	Jordan	5.8	9.0	0.0	4	5.2	5.3	6.8

Appendix1 continued

1245	Charleston Gray	United States	4.8	9.0	0.7	5	3.8	4.7	6.8
1246	PI 169263	Turkey	5.4	9.0	1.4	5	3.8	6.0	6.8
1247	PI 176488	Turkey	5.5	9.0	3.5	5	4.5	5.8	6.8
1248	PI 177329	Turkey	5.5	9.0	0.7	5	4.2	5.4	6.8
1249	PI 512363	Spain	5.7	9.0	1.4	5	4.5	6.0	6.8
1250	PI 175659	Turkey	5.7	8.0	0.7	4	5.0	5.3	6.8
1251	PI 219691	Pakistan	5.4	8.0	0.0	4	4.2	5.2	6.8
1252	PI 368497	Yugoslavia	5.4	9.0	0.0	4	3.7	5.8	6.8
1253	PI 379242	Yugoslavia	5.1	8.0	0.7	4	3.2	5.3	6.8
1254	PI 512402	Spain	5.6	9.0	0.0	4	4.5	5.5	6.8
1255	Calhoun Gray	United States	4.8	9.0	0.0	5	2.8	4.8	6.8
1256	PI 169284	Turkey	4.6	9.0	0.7	5	2.7	4.2	6.8
1257	PI 176494	Turkey	5.6	9.0	0.7	5	4.3	5.5	6.8
1258	PI 179886	India	5.5	9.0	0.0	5	4.2	5.5	6.8
1259	PI 180426	India	5.6	8.0	0.7	5	4.8	5.0	6.8
1260	PI 183399	India	5.3	8.0	0.0	5	4.3	4.8	6.8
1261	PI 189317	Nigeria	5.6	9.0	0.7	5	4.2	5.7	6.8
1262	PI 190050	Yugoslavia	6.0	9.0	0.7	5	5.3	5.8	6.8
1263	PI 219907	Afghanistan	5.7	9.0	3.5	5	4.3	5.8	6.8
1264	PI 228237	Israel	5.3	9.0	0.0	5	4.0	5.2	6.8
1265	PI 266028	Venezuela	4.6	9.0	0.0	5	2.3	4.7	6.8
1266	PI 278024	Turkey	5.2	8.0	0.0	5	3.5	5.3	6.8
1267	PI 278048	Turkey	5.5	9.0	0.7	5	4.3	5.3	6.8
1268	PI 293766	Soviet Union	5.2	9.0	0.7	5	3.2	5.7	6.8
1269	PI 357678	Yugoslavia	5.1	8.0	0.0	5	3.2	5.2	6.8
1270	PI 357699	Yugoslavia	5.5	8.0	0.0	5	4.7	5.0	6.8
1271	PI 368507	Yugoslavia	5.2	9.0	0.7	5	4.2	4.7	6.8
1272	PI 379253	Yugoslavia	5.8	9.0	2.1	5	5.2	5.5	6.8
1273	PI 476325	Ukraine	5.4	9.0	0.0	5	4.0	5.5	6.8
1274	PI 487459	Venezuela	5.1	9.0	0.0	5	3.2	5.2	6.8
1275	PI 512345	Spain	5.2	9.0	0.7	5	3.7	5.0	6.8
1276	PI 512346	Spain	4.9	9.0	0.0	5	3.2	4.8	6.8
1277	PI 512353	Spain	5.1	8.0	0.0	5	3.0	5.3	6.8
1278	PI 534534	Syria	5.7	9.0	0.0	5	4.5	5.7	6.8
1279	PI 560015	Nigeria	5.1	9.0	1.4	5	3.2	5.2	6.8
1280	PI 600950	United States	5.7	9.0	0.7	5	4.7	5.7	6.8
1281	PI 171583	Turkey	5.7	9.0	0.0	6	5.0	5.2	6.8
1282	PI 183023	India	5.6	9.0	0.0	6	4.2	5.8	6.8
1283	PI 269677	Belize	5.4	8.0	0.0	6	4.5	5.0	6.8

Appendix1 continued

1284	PI 270309	Philippines	5.8	9.0	0.0	6	5.0	5.7	6.8
1285	PI 278023	Turkey	5.8	9.0	0.0	6	4.8	5.7	6.8
1286	PI 319235	Japan	5.9	9.0	0.7	6	5.0	5.8	6.8
1287	PI 345544	Ukraine	5.1	9.0	0.7	6	3.7	4.7	6.8
1288	PI 357657	Yugoslavia	4.8	8.0	0.7	6	3.0	4.7	6.8
1289	PI 357686	Yugoslavia	4.9	9.0	0.7	6	3.8	4.2	6.8
1290	PI 357710	Yugoslavia	5.2	9.0	1.4	6	3.7	5.0	6.8
1291	PI 368496	Yugoslavia	5.7	9.0	2.1	6	4.5	5.7	6.8
1292	PI 368504	Yugoslavia	5.4	8.0	0.0	6	4.3	5.2	6.8
1293	PI 381708	India	5.2	9.0	0.7	6	3.5	5.2	6.8
1294	PI 381723	India	5.7	9.0	0.0	6	4.7	5.7	6.8
1295	PI 381736	India	5.4	9.0	1.4	6	4.2	5.3	6.8
1296	PI 381742	India	6.1	9.0	1.4	6	5.7	5.8	6.8
1297	PI 381751	India	5.5	9.0	2.1	6	3.3	6.3	6.8
1298	PI 482366	Zimbabwe	4.9	8.0	0.7	6	3.2	4.7	6.8
1299	PI 500346	Zambia	5.3	9.0	0.7	6	3.7	5.3	6.8
1300	PI 507865	Hungary	5.3	9.0	1.4	6	3.3	5.7	6.8
1301	PI 512358	Spain	5.2	9.0	1.4	6	4.0	4.7	6.8
1302	PI 512374	Spain	5.4	9.0	0.0	6	4.5	5.0	6.8
1303	PI 512393	Spain	5.6	9.0	0.7	6	4.8	5.0	6.8
1304	PI 512406	Spain	5.2	8.0	0.0	6	3.3	5.5	6.8
1305	PI 525097	Egypt	5.7	9.0	0.7	6	4.5	5.7	6.8
1306	PI 537268	Pakistan	5.4	9.0	2.1	6	4.2	5.2	6.8
1307	PI 537461	Spain	5.8	9.0	0.7	6	4.5	6.2	6.8
1308	PI 593376	China	5.5	9.0	0.0	6	4.3	5.3	6.8
1309	PI 600902	United States	4.9	9.0	0.0	6	2.8	5.0	6.8
1310	PI 601062	United States	5.4	9.0	0.7	6	4.3	5.2	6.8
1311	PI 601101	United States	5.1	9.0	0.7	6	3.5	5.0	6.8
1312	PI 635611	United States	4.7	9.0	0.7	6	2.8	4.5	6.8
1313	PI 185635	Ghana	5.7	9.0	2.1	2	4.5	5.9	6.9
1314	PI 288522	India	5.4	7.0	1.4	3	3.7	5.6	6.9
1315	PI 169289	Turkey	5.3	7.0	.	1	4.0	5.0	7.0
1316	PI 182176	Turkey	4.7	7.0	0.0	1	3.0	4.0	7.0
1317	PI 254428	Lebanon	4.3	7.0	0.0	1	3.0	3.0	7.0
1318	PI 266015	Venezuela	6.3	7.0	.	1	5.0	7.0	7.0
1319	PI 502318	Uzbekistan	2.7	7.0	0.0	1	0.0	1.0	7.0
1320	PI 536457	Maldives	6.0	7.0	.	1	5.0	6.0	7.0
1321	Princeton	United States	7.0	7.0	.	1	7.0	7.0	7.0
1322	Big Crimson	United States	7.0	7.0	.	2	7.0	7.0	7.0

Appendix1 continued

1323	Early Arizona	United States	7.0	9.0	.	2	6.5	7.5	7.0
1324	Golden	United States	5.5	8.0	.	2	5.0	5.3	7.0
1325	PI 306364	Gabon	6.3	7.0	.	2	5.0	7.0	7.0
1326	PI 386019	Iran	5.5	9.0	.	2	5.0	4.5	7.0
1327	Picnic	United States	6.2	7.0	.	2	5.0	6.5	7.0
1328	TendersweetOF	United States	6.5	7.0	.	2	5.5	7.0	7.0
1329	PI 182179	Turkey	5.8	9.0	0.0	3	3.7	6.7	7.0
1330	PI 278040	Turkey	5.5	9.0	0.0	3	4.5	5.0	7.0
1331	PI 381709	India	5.2	8.0	1.4	3	3.2	5.5	7.0
1332	PI 629103	India	4.8	9.0	0.0	3	3.2	5.0	7.0
1333	Grif 5598	India	4.9	8.0	0.7	4	3.2	5.0	7.0
1334	PI 164687	India	5.1	7.0	0.0	4	3.3	5.0	7.0
1335	PI 169281	Turkey	5.7	9.0	1.4	4	4.3	5.8	7.0
1336	PI 169285	Turkey	5.5	9.0	2.1	4	3.8	5.8	7.0
1337	PI 169287	Turkey	5.4	9.0	0.0	4	4.0	5.3	7.0
1338	PI 172795	Turkey	5.2	9.0	1.4	4	2.8	5.8	7.0
1339	PI 176919	Turkey	5.5	8.0	0.7	4	3.8	5.8	7.0
1340	PI 183299	India	5.8	9.0	0.0	4	5.2	5.3	7.0
1341	PI 214316	India	5.3	7.0	0.0	4	4.0	5.0	7.0
1342	PI 234287	Portugal	5.7	9.0	0.0	4	4.3	5.7	7.0
1343	PI 274785	India	4.7	9.0	0.0	4	2.5	4.7	7.0
1344	PI 278054	Turkey	5.6	9.0	0.0	4	4.0	5.8	7.0
1345	PI 344301	Turkey	5.3	8.0	0.0	4	3.0	5.8	7.0
1346	PI 357694	Yugoslavia	5.3	9.0	0.0	4	4.0	5.0	7.0
1347	PI 368509	Yugoslavia	5.8	9.0	1.4	4	4.3	6.0	7.0
1348	PI 368519	Yugoslavia	5.9	8.0	0.7	4	4.8	6.0	7.0
1349	PI 368530	Yugoslavia	6.1	9.0	1.4	4	5.2	6.0	7.0
1350	PI 379224	Yugoslavia	5.2	9.0	1.4	4	3.2	5.5	7.0
1351	PI 525084	Egypt	5.9	9.0	1.4	4	4.8	5.8	7.0
1352	PI 601308	United States	5.0	9.0	0.0	4	2.7	5.3	7.0
1353	PI 635604	United States	4.5	9.0	0.0	4	3.3	4.2	7.0
1354	Gray belle	United States	4.5	9.0	0.0	5	3.3	4.2	7.0
1355	PI 169246	Turkey	5.8	9.0	0.0	5	4.3	6.0	7.0
1356	PI 169259	Turkey	6.1	9.0	0.0	5	5.0	6.2	7.0
1357	PI 174100	Turkey	5.2	9.0	1.4	5	2.8	5.8	7.0
1358	PI 174107	Turkey	5.3	9.0	0.7	5	4.0	4.8	7.0
1359	PI 175652	Turkey	4.8	9.0	0.0	5	4.0	3.3	7.0
1360	PI 176499	Turkey	6.0	9.0	0.0	5	5.2	5.8	7.0
1361	PI 177328	Turkey	5.9	9.0	0.7	5	4.0	6.5	7.0

Appendix1 continued

1362	PI 177330	Syria	6.4	9.0	0.0	5	5.8	6.5	7.0
1363	PI 179662	India	4.7	9.0	0.7	5	2.4	4.6	7.0
1364	PI 182175	Turkey	5.9	9.0	1.4	5	4.7	6.2	7.0
1365	PI 182933	India	4.9	9.0	0.0	5	3.5	4.3	7.0
1366	PI 197416	Ethiopia	5.3	9.0	0.0	5	3.5	5.3	7.0
1367	PI 219906	Afghanistan	5.2	9.0	0.0	5	3.5	5.2	7.0
1368	PI 222711	Iran	5.5	9.0	2.1	5	3.7	5.8	7.0
1369	PI 222714	Iran	5.5	9.0	0.0	5	4.5	5.0	7.0
1370	PI 251515	Iran	5.8	9.0	0.0	5	4.3	6.2	7.0
1371	PI 270524	Israel	5.4	9.0	2.8	5	4.0	5.3	7.0
1372	PI 270548	Ghana	5.3	9.0	0.7	5	3.7	5.2	7.0
1373	PI 278032	Turkey	4.9	9.0	1.4	5	3.2	4.7	7.0
1374	PI 278052	Turkey	5.8	9.0	0.0	5	4.7	5.7	7.0
1375	PI 357680	Yugoslavia	5.1	9.0	0.0	5	3.8	4.3	7.0
1376	PI 370427	Yugoslavia	5.4	8.0	0.0	5	3.3	5.8	7.0
1377	PI 379239	Yugoslavia	4.7	9.0	0.0	5	2.2	4.8	7.0
1378	PI 381719	India	5.2	9.0	0.7	5	3.0	5.7	7.0
1379	PI 381725	India	5.8	9.0	0.7	5	4.7	5.7	7.0
1380	PI 381728	India	6.1	9.0	1.4	5	5.2	6.0	7.0
1381	PI 475746	Paraguay	6.0	9.0	1.4	5	5.5	5.5	7.0
1382	PI 512341	Spain	5.6	8.0	2.1	5	3.8	5.8	7.0
1383	PI 512378	Spain	5.9	9.0	0.7	5	5.0	5.8	7.0
1384	PI 525091	Egypt	5.4	9.0	0.0	5	3.7	5.7	7.0
1385	PI 629104	Syria	4.6	8.0	0.0	5	3.5	3.8	7.0
1386	PI 635597	United States	5.4	9.0	0.0	5	3.2	6.2	7.0
1387	PI 635609	United States	5.7	9.0	2.8	5	4.3	5.8	7.0
1388	PI 169245	Turkey	5.1	9.0	0.7	6	3.0	5.2	7.0
1389	PI 175653	Turkey	5.5	9.0	0.7	6	4.2	5.3	7.0
1390	PI 177318	Turkey	5.4	9.0	1.4	6	4.3	5.0	7.0
1391	PI 177326	Turkey	5.5	9.0	1.4	6	4.7	4.8	7.0
1392	PI 181744	Lebanon	5.7	9.0	0.7	6	4.3	5.7	7.0
1393	PI 227206	Japan	6.1	9.0	1.4	6	4.8	6.3	7.0
1394	PI 234605	United States	6.1	9.0	1.4	6	5.7	5.7	7.0
1395	PI 277982	Turkey	6.1	9.0	1.4	6	5.2	6.0	7.0
1396	PI 278004	Turkey	5.3	8.0	0.0	6	3.8	5.2	7.0
1397	PI 278009	Turkey	5.2	9.0	0.7	6	3.2	5.3	7.0
1398	PI 278061	Turkey	5.9	9.0	1.4	6	4.7	6.0	7.0
1399	PI 357697	Yugoslavia	5.3	8.0	0.7	6	3.7	5.3	7.0
1400	PI 357746	Yugoslavia	6.0	9.0	0.7	6	5.5	5.5	7.0

Appendix1 continued

1401	PI 381740	India	5.2	8.0	0.0	6	3.3	5.2	7.0
1402	PI 512359	Spain	5.9	9.0	0.0	6	5.0	5.8	7.0
1403	PI 512373	Spain	5.1	8.0	0.7	6	3.3	4.8	7.0
1404	PI 512375	Spain	5.5	9.0	0.7	6	4.5	5.0	7.0
1405	PI 512387	Spain	5.3	9.0	0.7	6	3.8	5.2	7.0
1406	PI 525088	Egypt	5.2	9.0	0.0	6	3.3	5.2	7.0
1407	PI 534583	Syria	5.6	9.0	1.4	6	4.0	5.8	7.0
1408	PI 534592	Syria	5.8	9.0	0.0	6	4.7	5.7	7.0
1409	PI 601382	United States	5.2	9.0	0.7	6	3.8	4.8	7.0
1410	PI 634691	United States	5.3	9.0	1.4	6	3.7	5.2	7.0
1411	PI 181935	Syria	5.5	7.0	0.0	3	3.8	5.6	7.1
1412	PI 314178	Soviet Union	5.8	8.0	0.7	3	4.8	5.5	7.1
1413	Grif 5600	India	5.3	9.0	2.1	4	3.3	5.3	7.2
1414	PI 169300	Turkey	5.7	9.0	0.7	4	5.0	5.0	7.2
1415	PI 175656	Turkey	6.4	9.0	0.0	4	5.8	6.3	7.2
1416	PI 176490	Turkey	5.7	8.0	2.1	4	4.2	5.7	7.2
1417	PI 278011	Turkey	6.1	9.0	0.7	4	5.0	6.0	7.2
1418	PI 278013	Turkey	6.0	9.0	0.0	4	5.0	5.8	7.2
1419	PI 278044	Turkey	5.3	9.0	0.7	4	3.3	5.5	7.2
1420	PI 278045	Turkey	5.7	9.0	0.7	4	4.5	5.5	7.2
1421	PI 307749	Philippines	5.1	8.0	0.0	4	3.5	4.7	7.2
1422	PI 357738	Yugoslavia	5.8	9.0	0.0	4	4.3	6.0	7.2
1423	PI 381703	India	5.6	8.0	0.7	4	3.7	6.0	7.2
1424	PI 175655	Turkey	6.3	9.0	0.7	5	5.5	6.3	7.2
1425	PI 177320	Turkey	5.2	9.0	0.0	5	2.7	5.8	7.2
1426	PI 182935	India	6.2	9.0	0.7	5	5.0	6.5	7.2
1427	PI 271747	Afghanistan	5.7	9.0	0.7	5	4.3	5.7	7.2
1428	PI 278008	Turkey	5.0	9.0	0.0	5	2.8	5.0	7.2
1429	PI 370426	Yugoslavia	5.7	8.0	0.0	5	4.0	5.8	7.2
1430	PI 490379	Mali	4.3	9.0	0.0	5	1.7	4.0	7.2
1431	PI 507859	Hungary	5.2	9.0	0.7	5	3.2	5.3	7.2
1432	PI 512369	Spain	5.4	9.0	0.7	5	3.5	5.7	7.2
1433	PI 534590	Syria	5.3	9.0	0.7	5	3.7	5.0	7.2
1434	PI 537269	Pakistan	5.5	9.0	0.7	5	4.3	5.0	7.2
1435	PI 537465	Spain	5.8	9.0	0.7	5	4.5	5.8	7.2
1436	PI 601063	United States	5.4	9.0	0.0	5	3.8	5.2	7.2
1437	PI 629108	United States	5.3	9.0	0.0	5	3.3	5.3	7.2
1438	PI 169291	Turkey	5.8	9.0	0.0	6	4.8	5.5	7.2
1439	PI 171582	Turkey	6.8	9.0	0.0	6	6.3	6.8	7.2

Appendix1 continued

1440	PI 179881	India	6.2	9.0	0.7	6	5.5	5.8	7.2
1441	PI 214044	India	5.8	9.0	0.0	6	4.3	5.8	7.2
1442	PI 270549	Ghana	5.3	9.0	1.4	6	3.5	5.2	7.2
1443	PI 271981	Somalia	6.3	9.0	0.7	6	6.0	5.8	7.2
1444	PI 277984	Turkey	5.7	9.0	1.4	6	4.0	6.0	7.2
1445	PI 357747	Yugoslavia	5.7	9.0	0.7	6	4.0	6.0	7.2
1446	PI 507861	Hungary	5.7	9.0	0.0	6	4.3	5.5	7.2
1447	PI 534599	Syria	5.9	9.0	0.7	6	4.5	6.2	7.2
1448	PI 537267	Pakistan	5.3	9.0	0.0	6	3.7	5.2	7.2
1449	PI 537276	Pakistan	5.9	9.0	0.7	6	4.7	5.8	7.2
1450	DMS-1	United States	4.4	8.0	0.0	4	2.5	4.5	7.2
1451	PI 169276	Turkey	5.3	8.0	0.0	4	3.5	5.3	7.2
1452	PI 177327	Turkey	5.9	9.0	1.4	4	4.6	6.0	7.2
1453	PI 277988	Turkey	6.1	9.0	1.4	4	5.0	6.2	7.2
1454	PI 216029	India	5.6	9.0	1.4	5	3.8	5.8	7.2
1455	PI 482378	Zimbabwe	4.1	8.0	0.7	5	1.7	4.2	7.2
1456	PI 357745	Yugoslavia	5.7	8.0	0.7	3	4.2	5.6	7.2
1457	PI 271750	Ghana	5.3	8.0	0.0	3	3.3	5.3	7.3
1458	PI 357669	Yugoslavia	5.9	8.0	0.7	3	5.0	5.5	7.3
1459	PI 169232	Turkey	5.8	9.0	0.0	4	4.3	6.0	7.3
1460	PI 169271	Turkey	4.6	9.0	0.0	4	2.5	4.0	7.3
1461	PI 179884	India	5.4	9.0	0.0	4	3.5	5.5	7.3
1462	PI 182934	India	6.9	9.0	2.1	4	6.5	7.0	7.3
1463	PI 251796	Yugoslavia	5.0	9.0	0.0	4	3.0	4.8	7.3
1464	PI 537470	Spain	5.8	9.0	0.7	4	4.0	6.0	7.3
1465	PI 169234	Turkey	5.1	8.0	1.4	5	2.8	5.3	7.3
1466	PI 169249	Turkey	5.8	9.0	2.1	5	5.0	5.3	7.3
1467	PI 278012	Turkey	5.5	8.0	0.7	5	3.8	5.5	7.3
1468	Golden Midget1	United States	5.3	9.0	1.4	3	4.8	5.0	7.3
1469	PI 223765	Afghanistan	5.7	8.0	0.0	3	3.7	6.0	7.3
1470	PI 536458	Maldives	5.6	9.0	0.0	3	4.0	5.3	7.3
1471	PI 172805	Turkey	7.4	9.0	0.0	4	7.3	7.7	7.3
1472	PI 176491	Turkey	5.7	9.0	0.0	4	3.8	6.0	7.3
1473	PI 207473	Afghanistan	5.4	9.0	0.0	4	3.8	5.0	7.3
1474	PI 212596	Afghanistan	6.2	9.0	0.7	4	5.3	6.0	7.3
1475	PI 254737	Senegal	5.4	9.0	0.7	4	3.7	5.3	7.3
1476	PI 518612	Soviet Union	5.3	9.0	0.7	4	2.7	5.8	7.3
1477	PI 542617	Algeria	6.3	9.0	0.0	4	4.7	7.0	7.3
1478	PI 164748	India	6.7	9.0	0.0	5	5.8	6.8	7.3

Appendix1 continued

1479	PI 171587	Turkey	5.7	9.0	0.7	5	3.8	5.8	7.3
1480	PI 172802	Turkey	5.1	9.0	0.7	5	3.2	4.7	7.3
1481	PI 182183	Turkey	5.3	9.0	0.0	5	3.3	5.2	7.3
1482	PI 193963	Ethiopia	5.8	9.0	0.7	5	4.8	5.3	7.3
1483	PI 222712	Iran	5.4	9.0	0.7	5	3.5	5.3	7.3
1484	PI 278021	Turkey	5.6	9.0	1.4	5	4.3	5.2	7.3
1485	PI 278043	Turkey	6.1	9.0	0.7	5	4.5	6.3	7.3
1486	PI 314148	Soviet Union	6.6	9.0	0.7	5	5.5	6.8	7.3
1487	PI 368527	Yugoslavia	5.8	9.0	0.7	5	4.0	6.0	7.3
1488	PI 379241	Yugoslavia	6.1	9.0	0.7	5	4.8	6.2	7.3
1489	PI 381714	India	5.7	9.0	0.7	5	3.7	6.0	7.3
1490	PI 381741	India	5.9	9.0	1.4	5	4.8	5.7	7.3
1491	PI 487458	Venezuela	5.8	9.0	0.0	5	4.2	5.8	7.3
1492	PI 512351	Spain	5.1	9.0	0.7	5	2.8	5.2	7.3
1493	PI 518611	Soviet Union	4.6	8.0	0.0	5	3.0	3.5	7.3
1494	PI 534532	Syria	6.0	9.0	0.0	5	4.5	6.2	7.3
1495	PI 534591	Syria	6.0	9.0	0.0	5	4.7	6.0	7.3
1496	PI 534596	Syria	5.7	9.0	0.7	5	4.2	5.7	7.3
1497	PI 629107	United States	6.6	9.0	0.0	5	5.2	7.3	7.3
1498	PI 174109	Turkey	6.6	9.0	0.0	6	5.8	6.7	7.3
1499	PI 223764	Afghanistan	6.2	9.0	0.0	6	5.5	5.7	7.3
1500	PI 276445	Jordan	5.9	9.0	0.0	6	4.7	5.8	7.3
1501	PI 278006	Turkey	6.2	9.0	0.0	6	5.3	6.0	7.3
1502	PI 507862	Hungary	5.7	9.0	0.0	6	4.0	5.8	7.3
1503	PI 525100	Italy	6.3	9.0	0.7	6	5.0	6.5	7.3
1504	PI 270522	Israel	5.0	7.0	0.0	1	2.8	4.9	7.4
1505	RhodeIslandRed	United States	5.5	9.0	1.4	5	4.0	5.7	7.4
1506	Black Boy	United States	6.7	8.0	.	2	5.5	7.0	7.5
1507	DMR-112	United States	6.8	9.0	.	2	5.0	8.0	7.5
1508	PI 386024	Iran	6.0	8.0	0.0	2	5.0	5.5	7.5
1509	PI 560018	Nigeria	4.5	9.0	0.0	2	1.5	4.5	7.5
1510	Sugarloaf	United States	7.0	8.0	.	2	6.5	7.0	7.5
1511	Black Diamond YB	United States	6.0	8.0	0.0	3	5.0	5.5	7.5
1512	PI 169243	Turkey	5.8	7.0	0.0	3	4.8	5.3	7.5
1513	PI 269465	Pakistan	5.9	9.0	0.0	3	5.0	5.3	7.5
1514	PI 278020	Turkey	6.2	9.0	0.7	3	5.5	5.7	7.5
1515	PI 512344	Spain	5.4	8.0	0.0	3	3.5	5.3	7.5
1516	Grif 14199	India	5.8	9.0	0.7	4	4.5	5.3	7.5
1517	PI 169253	Turkey	5.8	8.0	0.0	4	4.3	5.8	7.5

Appendix1 continued

1518	PI 169275	Turkey	6.1	8.0	1.4	4	5.0	5.8	7.5
1519	PI 169279	Turkey	5.6	8.0	1.4	4	3.8	5.5	7.5
1520	PI 172796	Turkey	5.3	9.0	0.7	4	2.3	6.0	7.5
1521	PI 226459	Iran	7.1	9.0	0.0	4	6.5	7.2	7.5
1522	PI 250146	Pakistan	5.8	9.0	0.0	4	4.0	6.0	7.5
1523	PI 274795	Pakistan	5.6	9.0	0.0	4	3.8	5.5	7.5
1524	PI 277973	Turkey	5.8	9.0	0.7	4	4.5	5.3	7.5
1525	PI 357670	Yugoslavia	5.3	8.0	0.7	4	3.8	4.8	7.5
1526	PI 357671	Yugoslavia	5.6	8.0	0.7	4	4.0	5.3	7.5
1527	PI 357737	Yugoslavia	5.3	9.0	0.7	4	3.0	5.5	7.5
1528	PI 379234	Yugoslavia	6.2	9.0	0.7	4	5.3	5.8	7.5
1529	PI 379235	Yugoslavia	4.9	9.0	0.0	4	2.8	4.5	7.5
1530	PI 536453	Maldives	7.3	9.0	0.0	4	6.7	7.7	7.5
1531	PI 612470	South Korea	5.4	9.0	0.7	4	3.5	5.3	7.5
1532	Sweet Princess	United States	5.6	9.0	0.0	4	3.5	5.8	7.5
1533	Grif 5595	India	5.8	9.0	0.0	5	3.8	6.2	7.5
1534	PI 169251	Turkey	5.6	9.0	1.4	5	4.0	5.3	7.5
1535	PI 169294	Turkey	6.2	9.0	0.7	5	4.0	7.0	7.5
1536	PI 178873	Turkey	6.0	9.0	0.7	5	4.3	6.2	7.5
1537	PI 183125	India	6.6	9.0	0.0	5	5.3	7.0	7.5
1538	PI 254716	Sudan	6.1	9.0	0.7	5	5.2	5.7	7.5
1539	PI 275631	India	6.2	9.0	0.0	5	4.3	6.7	7.5
1540	PI 306366	Taiwan	5.4	9.0	2.1	5	3.2	5.5	7.5
1541	PI 357734	Yugoslavia	6.0	9.0	0.7	5	4.5	6.0	7.5
1542	PI 512367	Spain	5.6	9.0	0.0	5	3.5	5.7	7.5
1543	PI 534533	Syria	6.1	9.0	0.0	5	4.7	6.2	7.5
1544	PI 175660	Turkey	6.5	9.0	0.0	6	5.3	6.7	7.5
1545	PI 176487	Turkey	5.3	9.0	0.0	6	3.3	5.2	7.5
1546	PI 277994	Turkey	6.0	9.0	0.7	6	5.0	5.5	7.5
1547	PI 278058	Turkey	5.5	9.0	0.0	6	3.3	5.7	7.5
1548	PI 512386	Spain	5.3	9.0	0.0	6	3.0	5.5	7.5
1549	PI 181868	Syria	5.3	9.0	0.0	3	3.2	5.2	7.6
1550	Black Diamond YlF	United States	6.4	9.0	0.0	4	6.2	6.5	7.6
1551	PI 635610	United States	6.3	9.0	0.0	4	5.7	6.7	7.6
1552	PI 172801	Turkey	5.6	9.0	0.0	5	3.7	6.2	7.6
1553	PI 226634	Iran	6.8	9.0	0.0	2	5.7	7.0	7.7
1554	PI 254429	Lebanon	6.3	9.0	0.0	3	4.3	7.0	7.7
1555	Grif 15895	Canada	6.3	8.0	0.0	4	4.7	6.5	7.7
1556	PI 171579	Turkey	6.0	9.0	0.0	4	4.3	6.0	7.7

Appendix1 continued

1557	PI 179878	India	5.7	9.0	0.0	4	4.3	5.0	7.7
1558	PI 207471	Afghanistan	6.7	9.0	0.0	4	5.5	7.0	7.7
1559	PI 164804	India	6.9	9.0	0.0	5	6.0	7.0	7.7
1560	PI 182181	Turkey	6.8	9.0	0.7	5	5.5	7.2	7.7
1561	PI 182932	India	6.5	9.0	0.0	5	5.7	6.2	7.7
1562	PI 200733	Guatemala	6.4	9.0	1.4	5	4.7	6.8	7.7
1563	PI 274561	Portugal	5.8	9.0	1.4	5	4.0	5.8	7.7
1564	PI 525087	Egypt	6.7	9.0	1.4	5	6.0	6.5	7.7
1565	PI 536451	Maldives	7.0	9.0	0.0	5	6.3	7.0	7.7
1566	PI 537468	Spain	5.8	9.0	0.7	5	4.2	5.5	7.7
1567	PI 593347	China	6.3	9.0	0.7	5	5.2	6.0	7.7
1568	PI 167059	Turkey	5.4	9.0	0.7	6	2.7	6.0	7.7
1569	PI 180427	India	6.4	9.0	0.0	6	5.5	6.0	7.7
1570	PI 278060	Turkey	6.6	.	.	0	5.0	7.2	7.7
1571	PI 169269	Turkey	5.1	8.0	0.0	3	3.2	5.7	7.8
1572	PI 270525	Israel	5.8	9.0	0.7	3	3.8	6.0	7.8
1573	PI 525085	Egypt	5.8	8.0	0.0	3	5.0	4.5	7.8
1574	PI 169250	Turkey	5.6	8.0	0.0	4	3.5	5.5	7.8
1575	PI 169288	Turkey	5.6	9.0	0.7	4	3.5	5.5	7.8
1576	PI 179237	Turkey	6.7	9.0	1.4	4	5.0	7.3	7.8
1577	PI 278053	Turkey	6.4	9.0	1.4	4	6.0	5.5	7.8
1578	Sugar Baby	United States	6.1	9.0	0.0	4	4.8	5.8	7.8
1579	PI 270144	Greece	5.3	9.0	0.0	5	3.8	4.3	7.8
1580	PI 169256	Turkey	6.4	9.0	0.0	4	4.7	7.0	7.8
1581	PI 629105	United States	5.9	9.0	0.7	5	4.5	6.2	7.8
1582	PI 183123	India	6.1	9.0	0.0	5	3.5	7.0	7.8
1583	PI 381716	India	5.2	9.0	0.7	5	3.2	4.5	7.8
1584	PI 164665	India	6.1	9.0	0.7	6	4.7	5.8	7.8
1585	PI 169290	Turkey	5.6	9.0	0.0	6	3.5	5.5	7.8
1586	PI 171586	Turkey	5.6	9.0	0.7	6	4.0	5.0	7.8
1587	PI 512397	Spain	6.4	9.0	0.0	6	4.8	6.5	7.8
1588	PI 536452	Maldives	7.2	9.0	0.0	6	6.7	7.2	7.8
1589	PI 271988	Somalia	4.7	8.0	0.0	1	2.0	4.0	8.0
1590	Carolina Cross#18	United States	7.3	9.0	.	2	6.5	7.5	8.0
1591	Champion#2	United States	7.5	8.0	.	2	7.0	7.5	8.0
1592	Charlee	United States	7.3	8.0	.	2	7.0	7.0	8.0
1593	NC Giant 2	United States	6.4	9.0	0.0	2	6.3	6.3	8.0
1594	PI 174108	Turkey	6.8	9.0	.	2	5.5	7.0	8.0
1595	Sun Gold	United States	7.5	8.0	.	2	7.0	7.5	8.0

Appendix1 continued

1596	Grif 14201	India	5.8	8.0	.	3	3.0	6.5	8.0
1597	PI 169277	Turkey	5.3	9.0	1.4	3	3.0	5.0	8.0
1598	PI 169282	Turkey	6.0	9.0	0.0	3	4.3	5.7	8.0
1599	PI 172791	Turkey	5.9	9.0	0.0	3	4.0	5.8	8.0
1600	PI 176918	Turkey	6.1	9.0	0.0	3	4.8	5.5	8.0
1601	PI 278031	Turkey	5.8	9.0	0.0	3	4.0	5.3	8.0
1602	PI 278037	Turkey	6.8	9.0	0.0	3	5.7	6.7	8.0
1603	PI 183124	India	6.0	9.0	0.0	4	3.8	6.3	8.0
1604	PI 212094	Afghanistan	7.1	9.0	0.0	4	6.0	7.2	8.0
1605	PI 277996	Turkey	5.4	9.0	1.4	4	4.0	5.5	8.0
1606	PI 357726	Yugoslavia	6.7	9.0	0.0	4	5.3	6.8	8.0
1607	PI 379254	Yugoslavia	6.3	9.0	0.7	4	4.7	6.2	8.0
1608	PI 537300	Turkmenistan	6.4	9.0	0.7	4	5.0	6.3	8.0
1609	PI 635598	United States	7.3	9.0	1.4	4	6.8	7.2	8.0
1610	Stone Mountain	United States	6.5	9.0	1.4	4	4.8	6.8	8.0
1611	PI 164708	India	6.3	9.0	0.7	5	5.0	5.8	8.0
1612	PI 175662	Turkey	6.5	9.0	0.0	5	4.7	6.8	8.0
1613	PI 512828	Spain	6.1	9.0	0.0	5	3.7	6.7	8.0
1614	PI 518610	Russia	6.2	9.0	0.0	5	4.3	6.2	8.0
1615	PI 593371	China	6.9	9.0	0.0	5	5.7	7.2	8.0
1616	PI 593381	China	6.8	9.0	0.7	5	5.8	6.7	8.0
1617	PI 176908	Turkey	5.8	9.0	0.0	6	4.5	5.0	8.0
1618	PI 381737	India	5.9	9.0	0.0	4	4.0	5.5	8.2
1619	PI 435282	Iraq	5.9	9.0	0.7	4	3.7	6.0	8.2
1620	PI 278018	Turkey	5.8	9.0	0.0	4	4.0	6.2	8.2
1621	PI 177319	Turkey	5.9	9.0	0.0	3	4.5	5.0	8.3
1622	PI 211849	Iran	7.6	9.0	0.0	3	6.5	8.0	8.3
1623	PI 278055	Turkey	6.2	9.0	0.7	4	4.0	6.3	8.3
1624	PI 169241	Turkey	6.6	9.0	0.7	5	5.5	6.0	8.3
1625	PI 357666	Yugoslavia	6.7	9.0	0.0	4	4.7	7.0	8.3
1626	PI 277989	Turkey	6.7	9.0	1.4	5	5.0	6.7	8.3
1627	PI 536455	Maldives	7.8	9.0	0.0	5	7.8	7.3	8.3
1628	PI 176493	Turkey	6.5	9.0	0.0	4	4.6	6.6	8.4
1629	PI 169286	Turkey	7.1	9.0	0.0	3	5.3	7.5	8.5
1630	PI 169242	Turkey	6.9	9.0	0.0	4	6.0	6.3	8.5
1631	PI 172787	Turkey	5.7	9.0	1.4	4	4.0	6.0	8.5
1632	PI 176922	Turkey	6.3	9.0	0.0	4	3.3	7.0	8.5
1633	PI 222715	Iran	7.1	9.0	0.0	4	5.3	7.3	8.5
1634	PI 278041	Turkey	6.0	9.0	1.4	4	3.3	6.3	8.5

Appendix1 continued

1635	PI 536460	Maldives	7.2	9.0	0.0	4	5.3	7.8	8.5
1636	PI 537472	Spain	7.3	9.0	0.0	4	5.3	8.0	8.5
1637	PI 525090	Egypt	5.9	9.0	0.0	5	3.3	6.0	8.5
1638	PI 536459	Maldives	7.4	9.0	0.0	5	6.0	7.8	8.5
1639	PI 212288	Afghanistan	6.8	9.0	0.0	4	4.8	6.8	8.8
1640	PI 357725	Yugoslavia	6.6	9.0	0.7	4	4.3	6.8	8.8
1641	PI 357751	Yugoslavia	8.0	9.0	0.0	4	7.3	8.0	8.8
1642	PI 536454	Maldives	6.7	9.0	0.0	4	6.0	7.0	8.8
1643	PI 183217	Egypt	9.0	9.0	0.0	1	9.0	9.0	9.0
1644	PI 278036	Turkey	9.0	9.0	0.0	1	9.0	9.0	9.0
1645	PI 386021	Iran	4.7	9.0	0.0	1	0.0	5.0	9.0
1646	PI 559995	Nigeria	9.0	9.0	0.0	1	9.0	9.0	9.0
1647	PI 632751	Namibia	9.0	9.0	0.0	1	9.0	9.0	9.0
1648	Giza	United States	8.2	9.0	.	2	7.5	8.0	9.0
1649	Hopi Red Flesh	United States	7.8	9.0	.	2	6.0	8.5	9.0
1650	PI 536461	Maldives	9.0	9.0	.	2	9.0	9.0	9.0
1651	PI 559994	Nigeria	7.7	9.0	0.0	2	6.0	8.0	9.0
1652	PI 536462	Maldives	8.2	9.0	0.0	3	7.7	7.8	9.0
1653	PI 536464	Maldives	7.3	9.0	0.0	3	5.7	7.3	9.0
1654	PI 183398	India	6.8	9.0	0.0	4	4.3	7.3	9.0
1655	PI 536463	Maldives	7.6	9.0	0.0	4	6.3	7.3	9.0
	LSD (0.05)		2.0	2.0	-	-	2.0	2.0	2.0

†Mean of all ratings over 3 years from 2011 to 2013.
‡ Mean of the maximum ratings over 3 years from 2011 to 2013.
§ Standard deviation for 3rd ratings.
¶ Number of replications in 3rd ratings.
# 1st 2011 and 2012 started at the 8th week after planting, and the first rating for 2013 started at the 3rd week after planting, 1 week after inoculation; 2nd for 2011 and 2012 started at the 9th week after planting, and the second rating for 2013 started at the 4th week after planting, 2 weeks after inoculation; 3rd for 2011 and 2012 started at the 10th week after planting, and the third rating for 2013 started at the 5th week after planting, 3 weeks after inoculation; equals to the mean of best ratings over 3 years from 2011 to 2013.