Abstract

GUNER, NIHAT. *Papaya Ringspot Virus Watermelon Strain* and *Zucchini Yellow Mosaic Virus* Resistance in Watermelon. (under the direction of Dr. Todd C. Wehner)

Watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai) is a major crop in the southern United States. *Papaya ringspot virus*-watermelon strain (PRSV-W, formerly *Watermelon mosaic virus-1*) and *Zucchini yellow mosaic virus* (ZYMV) affect all agricultural species of the *Cucurbitaceae* and are of great economic importance because of their destructiveness. Watermelon has not been screened extensively for resistance to PRSV-W. Although there is a resistance source for ZYMV resistance, the identification of additional sources of resistance to ZYMV would be highly desirable since the initial sources of resistance are temperature dependent, or not resistant to some of the more severe strains of the virus. The objectives of this study were 1) to screen the USDA watermelon germplasm collection along with available watermelon cultivars for PRSV-W resistance; 2) to verify the disease rating for the most resistant and most susceptible accessions; 3) to determine the genetic control of PRSV-W resistance; and 4) to screen the U.S.D.A. watermelon germplasm collection along with available watermelon cultivars to identify additional sources of resistance to ZYMV. A total of 1275 plant introduction accessions and 44 watermelon cultivars were screened for PRSV-W resistance. The experiment was a randomized complete block with five replications. Enzyme-linked immunosorbent assay (ELISA) was performed after the last rating to determine whether the virus was in the plant tissue. After the germplasm screening, the most resistant and most susceptible cultigens were retested to verify their reactions. Of the 60 resistant PI accessions in the final retest, eight had resistance with a rating of 3.6 or less for the best, average and maximum ratings: PI 244017, PI 244019, PI 482342, PI 482318, PI 485583, PI 482379, PI 595203, and PI 244018. None of the watermelon cultivars tested exhibited resistance to PRSV-W. Inheritance of PRSV-W resistance was studied in three *C. lanatus var. citroides* accessions: PI 244017, PI 244019, and PI 485583. Three susceptible parent lines, 'Allsweet', 'Calhoun Gray', and 'New Hampshire Midget', were crossed with resistant accessions to develop F1, F2, and BC1 generations for six families. A single

recessive gene was found to control resistance to PRSV-W in all three resistant PI accessions. A test of allelism indicated that resistance to PRSV-W in the three PI accessions was due to the same gene. Therefore, the gene symbol '*prv*' is proposed for PRSV-W resistance in PI 244017, PI 244019, and PI 485583 in watermelon.

The USDA germplasm collection of 1613 introduction accessions, as well as 41 watermelon cultivars, was screened for resistance to the Florida strain of *Zucchini yellow mosaic virus* (ZYMV-FL). The experiment was a randomized complete block with four replications. A retest study was conducted after the germplasm screening to verify the reaction of the most resistant and susceptible accessions. The PI accessions with the highest resistance to ZYMV were PI 595203, PI 537277, PI 560016, PI 386016, PI 386019, PI 485580, PI 494529, and PI 595200. PI 595203 was the most resistant accession based on both the germplasm screening and the retest study. PI accessions with the highest resistance to ZYMV-FL that also had resistance to other watermelon viruses PRSV-W and WMV (*Watermelon mosaic virus*, formerly *Watermelon mosaic virus-2*) were PI 595203, PI 386015, PI 386016, PI 386024, PI 386025, PI 386026, PI 244018, PI 244019, PI 485583, and PI 494528, PI 494529.

Papaya Ringspot Virus Watermelon Strain and *Zucchini Yellow Mosaic Virus* Resistance in Watermelon

by

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A dissertation submitted to the Graduate Faculty of North Carolina State University in partial fulfillment of the requirements for the Degree of

Doctor of Philosophy

Department of Horticultural Science

Raleigh

2004

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Dedication

I dedicate all the work and effort that has gone into this project to the Turkish People who supported my study with their hearts and tax money.

Biography

Nihat Guner was born on 21 June 1971 to Muzaffer and Sahizar Guner in Samsun, Turkey. Although he grew up in a city, he visited his grandfather's farm every summer for helping them in agricultural work where his love of plants started. Nihat spent most of his childhood in Samsun. He attended Namik Kemal High School in Samsun, from 1985 to 1988. After graduation, he took a national exam to be eligible for access to university studies. He chose to major in Horticulture, which was not a popular area of study. Also, it would be difficult to find a job after graduation due to many graduates in that area at that time in Turkey. In 1989, he enrolled in Ankara University, Faculty of Agriculture where he obtained a Bachelor of Science degree in Horticultural Science. He greatly enjoyed studying plant science during his bachelor degree, and his interest in plant science made him a successful student. He was so interested in mushroom production while taking a mushroom production class that he grew mushrooms in a small container under his bed in the university dormitory where he lived for six years. Dormitory life taught him how to get along with people and how to share. Due to his success, Nihat received scholarships from the Council of Higher Education of Turkey, the University of Ankara, and the Prof. Dr. Nail Oraman Outstanding Student Scholarship during undergraduate studies. Nihat was ranked 1st in the IAESE (International Association for the Exchange of Students for Technical Experience) exam at the University of Ankara, Faculty of Agriculture, enabling his to qualify for practical training abroad. He did his practical training at the University of Tanta, Egypt. He graduated with a Bachelor's Degree in 1993 and in same year, started his master study at the same institute under the direction of Dr. Nilgun Halloran. At the same time, he worked as a cashier at the dormitory dining house. When there were no customers in line, the chef put him to work in the kitchen. Thus, he learned to cook and to peel potatoes. This skill helped him a lot when he got married.

While he was doing his master study, Nihat took the opportunity to test with qualified Horticulturists in the National Competitive Scholarship Exam for M.S. and Ph.D. study in U.S. held by the Turkish Ministry of Education, where he ranked second. With this scholarship, he took a six month English course in Sacramento, CA before he enrolled at Oregon State University in the Department of Horticulture in 1997 to study with Dr. Jim R. Myers. His Master of Science thesis research was on the

characterization of an architectural mutant of bean (*Phaseolus vulgaris* L.). Upon completion of his masters he worked as a research scientist about 8 months with Dr. Jim R. Myers on several research projects including popping bean project.

In 1999, he enrolled at North Carolina State University for a Ph.D. under direction of Dr. Todd C. Wehner working on watermelon breeding. His research involved screening the two potyviruses that have a tremendous negative effect on watermelon production areas in the world as well as in the U.S. Nihat also gained field and greenhouse breeding experience working with other cucurbits like cucumber, melon and luffa in the cucurbit breeding project. He conducted a survey with Dr. Todd C. Wehner on training of plant breeding students in the U.S. to determine the number of domestic and international plant breeding students graduating at the M.S. and Ph.D. levels from plant breeding programs in 1995 to 2000. While at NC State, Nihat was initiated into the honor society of Pi Alpha Xi. As a member, he volunteered at the society's spring and fall fundraising plant sales.

Following the completion of his Ph.D. degree, Nihat will be working as a project leader and watermelon breeder at the Florida Research Station of Sakata Seed America Inc. located in Fort Myers.

Acknowledgments

I would like to express my sincere appreciation to my major professor Dr. Todd C. Wehner for his patient guidance, understanding, advice, assistance, encouragement and friendship during my research. I am also thankful to my graduate committee members Dr. G. Craig Yencho, Dr. Zvezdana Pesic-VanEsbroeck, Dr. Ted H. Emigh, and Dr. Steven A. Lommel for their contributions to this dissertation, their advice and helpful suggestions. A special thanks to Dr. Jules Silverman for being my graduate school representative.

I also would like to thank the Turkish people for their financial sponsorship that has allowed me to pursue a graduate degree in the U.S. Special thanks go to all the people I have had the opportunity to work with and share excellent moments with, and the friendships that have developed. I would especially like to thank Tammy Ellington for her help and friendship.

I owe special thanks to Mr. Bruton Strange who kindly taught me all the techniques he learned from his study when I took over the project. I thank Gabriele Gusmini for his friendly interaction and encouragement at all times. I want to extend my appreciation to my relatives and supporters Ibrahim and Ulku Cakir, Ibrahim and Ayse Onen and my friends Salih Kose, Mustafa Kililioglu. You were always there when I needed you.

I am forever thankful to my mother who was always with me in my heart during my studies although she was living in another part of the world. She was the person made this journey possible. I also owe a huge thanks to my brother and sister for their support and encouragement.

My deepest gratitude and love goes to my wife, Saime Hilal. I thank her for many things, but especially for her affection, patience, support, and encouragement.

Finally, I am thankful to ALLAH (God) that I was able to complete my study with His permission. Elhamdulillah. Rabbi zidni ‘ilmaa (O Allah increase me in my knowledge). Amin.

Table of Contents

List of Tables

General Introduction

Watermelon [*Citrullus lanatus* var. *lanatus* (Thunb.) Matsum. & Nakai], formerly *C. vulgaris*, together with cucumber, melon, squash, and pumpkin are the principal food plants of the gourd family (*Cucurbitaceae*). The family *Cucurbitaceae* contains about 118 genera and over 800 species. The genus *Citrullus* has four species (*C. lanatus*, *C. ecirrhosus*, *C. colocynthis*, and *C. rehmii*). *C. rehmii* was most recently described as a valid species of the genus *Citrullus* by De Winter, (1990). All species in the genus are cross compatible with each other to varying degrees. *C. ecirrhosus*, which is endemic to the Namibian desert (Zamir et al.1984), and *C. lanatus* appear to be more closely related to each other than either is to *C. colocynthis* (Navot and Zamir, 1987). Cultivated watermelon (*C. lanatus*) is an annual, mostly monoecious diploid (2n=2x=22) (Shimotsuma, 1963).

Commercial cultivars are classified as *C. lanatus* var. *lanatus*, and wild accessions are *C. lanatus* var. *citroides* (L.H. Bailey) (Wehner et al. 2001). The fruit of the domesticated watermelon varies from globose to oblong or cylindrical with solid dark or light green, and gray with mottled or striped rind pattern. Edible flesh color can be dark red, light red, canary yellow, salmon yellow, or white. Fruit size can be ice box, small, medium, large, and giant. *C. lanatus* var. *citroides*, which are common in central Africa, probably gave rise to domesticated *C. lanatus* var. *lanatus* (Robinson and Decker-Walters, 1997). *Citrullus lanatus*, var. *citroides* Mansf. is known as the citron or preserving melon. Its rind is used to make pickles, and the fruit are fed to livestock (Jeffrey, 1975). Citrons produce small fruit with hard, inedible white and bitter flesh, and green or tan seeds. The seeds of the citron are not marked or marbled as sometimes is seen in *C. lanatus* var. *lanatus*, the domesticated watermelon. An unusual seed mutant in watermelon (*Citrullus lanatus* var. *lanatus*) has seeds with a fleshy pericarp, commonly called Egusi seeds. The origin of the phenotype is unknown, but it is widely cultivated in Nigeria (Anuebunwa 2000; Ezeike and Otten 1989, 1991; Jolaoso et al. 1996) for the high protein and carbohydrate content of the edible seeds. Egusi seeds have thick, fleshy pericarp that appears during the second/third week of fruit development. The fruit are not edible because of their bitter, hard, white flesh (Gusmini et al. 2004).

Watermelon is grown throughout the world as a staple food (edible seeds), a dessert food (edible flesh), and for animal feed. The fruit can be eaten fresh or cooked. The rind can be pickled or candied.

The juice from the fruit can be used fresh, made into a fermented drink, or boiled down into heavy syrup. Watermelon seeds are baked or roasted for consumption. Their fleshy, juicy, sweet fruit provide a delicious refreshing dessert in hot weather. In some cases the fruit can serve as a source of water, especially in deserts or where drinking water is contaminated (Rubatzky, 2001).

C. lanatus is a cultivated species thought to have originated in southern Africa near the Kalahari Desert (Rubatzky, 2001; Mohr, 1986). Whitaker and Davis (1962) also describe the existence of a secondary diversification center in India. Watermelon has been cultivated in Africa and the Middle East for thousands of years. Cultivation of watermelon began in ancient Egypt and India, and is thought to have spread from those countries through the Mediterranean, Near East, and Asia. Watermelon made its way to America with African slaves and European colonists in the 1500s (Rubatzky, 2001).

Watermelon is a major cucurbit crop that accounts for 7.5% of the world area devoted to vegetable production in 2003. Worldwide, watermelons are grown on over 3.7 million ha and produce more than 83 million metric tons of fruit, with China and the Middle Eastern countries the major producers and consumers. There are no estimates of farm gate value of the world's watermelon crop. However, one can project a rough estimate of annual world value exceeding $15 billion using the United State average price of $9.0 per cwt for 2003. Watermelon is grown in more than 96 countries worldwide. China is the world leader in watermelon production with 70.3% of the total production in 2003. Other leading countries are Turkey (4.7%), Iran (2.3%), the United States (2.2%), and Egypt (1.7%) (FAO, 2003).

In the United States, watermelon was harvested from 161,000 acres with a total production of 38,4 million cwt (average yield 257 cwt/A) and a total value of $346 million in 2003, up about 20% from a decade earlier. Leading producers of watermelons in the U.S. are Texas, Florida California, Georgia, and Arizona. North Carolina ranked 8th in production (1.1 million cwt) and 5th in harvested area (8,800 acres) in 2003 (USDA 2003). The United States watermelon crop accounted for 9.2% of the harvested area, 10.0% of the production, and 3.5% of the value of the United States fresh vegetable industry in 1999. Worldwide watermelon consumption average is 17 lb/per capita/a year in 1996. Consumption in the world's leading producing countries varies from 17 lb in the United States to 138 lb/per capita/a year in Turkey (Maynard, 2001).

Watermelon has become an important part of the healthy diet since nutritionally it is free of fat, sodium and cholesterol. The fruit contains 93-95% water, 5% carbohydrate, 0.5-1% protein, and 0.2% fat (Rubatzky and Yamaguchi, 1997). Watermelon was approved a heart-healthy food by the American Heart Association. Watermelon is the leader among fresh fruits and vegetables in lycopene, which was classified as a useful component of human diet for prevention of heart attacks and certain cancers. Watermelon contains 60% more lycopene than tomato. Recently, it has been found that watermelon rind contains an important natural compound called citrulline, an amino acid that the human body makes from food. Citrulline, found in high concentration in the liver, promotes energy and assists with the immune system (Perkins-Veazie et al., 2001). One of the key roles of citrulline is to create another amino acid, argenine, that plays an important role in wound healing, detoxification reactions, immune functions, and promoting the secretion of several hormones including insulin and growth hormone (Flynn et al., 2002). Watermelon is also excellent source of beta-carotene and vitamin C, while the seeds are high in vitamin E and in the antioxidant minerals zinc and selenium.

Plant diseases caused by viruses are a major limiting factor in commercial watermelon production worldwide. There are over 10 viruses known to be a problem in watermelon production (Provvidenti, 1986b). The major viruses affecting watermelon in the United States are *Papaya ringspot virus-watermelon strain* (PRSV-W, formerly *Watermelon mosaic virus-1*), *Watermelon mosaic virus* (WMV, formerly *Watermelon mosaic virus-2*), and *Zucchini yellow mosaic* (ZYMV) (Adlerz and Crall, 1967; Mohr, 1986; Provvidenti, 1991; Wehner et al., 2001). Fields may be infected with individual viruses, or with multiple viruses in combination (Davis and Mizuki, 1987). Virus diseases are destructive to the watermelon crop, and are difficult to control (Sherf and Macnab, 1986). Plants infected with PRSV-W lose their photosynthetic capacity and subsequently display stunted growth, deformed fruit, and early mortality. Although resistance is generally pathogen-specific (Grumet, 1989), the most economical method is genetic resistance.

Papaya ringspot virus (PRSV) causes one of the most prominent diseases in papaya (*Carica papaya* L.) and in members of Chenopodiaceae and Cucurbitaceae families (Purcifull et al., 1984). PRSV is in the family *Potyviridae*, which forms the largest family of plant viruses, with 193 species (Shukla et al., 1994).

PRSV was first described in papaya (PRSV-P) by Jensen (1949) and in cucurbits (PRSV-W) by Webb and Scott (1965). PRSV-P is thought to have arisen by mutation from PRSV-W. PRSV may have arisen in Asia in the region of the Indian subcontinent (Sri Lanka) (Bateson et al., 2002). PRSV-W was considered for a long time to be a distinct potyvirus, WMV-1 Webb and Scott (1965). However, the P and W isolates were found to be indistinguishable serologically (Gonsalves and Ishii, 1980) and now are considered strains of *Papaya ringspot virus* (Suzuki et al., 1990; Purcifull et al., 1984; Purcifull and Hiebert, 1979; Baker et al., 1991; Quiot-Douine 1990 and 1986). The main reason for the early confusion about the taxonomic status of the W isolate was that it does not infect papaya. However, the P isolates infect cucurbits in nature as well as papaya (Gonsalves, 1998; Tennant et al., 1994; Provvidenti, 1993).

PRSV-W is in the family *Potyviridae*. It is transmitted in a non-persistent manner by 24 aphid species in 15 genera with *Myzus persicae*, *Aulacorthum solani*, *Aphis craccivora*, and *Macrosiphum euphorbiae* as natural vectors. PRSV-W is a potyvirus whose genome consists of unipartite, single-stranded, linear RNA. Its total genome size is 12 kb and codes for 8 proteins. PRSV-W induce pinwheel and scroll types of cytoplasmic cylindrical inclusions in infected host cells (Purcifull et al., 1984). Type W isolates are reported to infect 38 species in 11 genera of Cucurbitaceae, and two species of Chenopodiaceae, with squash, watermelon, cucumber, and cantaloupe among the commercially important natural hosts. The virus is not seed transmitted. It appears to over winter in wild species of Cucurbitaceae and Chenopodiaceae (Purcifull and Hiebert, 1979). There are many isolates of PRSV-W found throughout the world, but the isolates used in this study came only from Florida.

Control strategies of PRSV-W consist of earlier crop planting, using colored or reflective mulches, using insecticides to eliminate the vectors, and using herbicides to eliminate the alternate hosts (Conway et al., 1989). These control strategies are generally unsuccessful due to the short period of time it takes for the vector to transmit the virus from an infected plant to an uninfected plant, and the difficulty in removing all alternate hosts from crop production areas. Thus, genetic resistance is considered to be the most economical and environmentally friendly approach to virus control (Shukla et al., 1994).

Cross protection occurs when plants are inoculated with a weakened or symptomless strain of a virus to prevent symptoms when the plant is infected with the normal strain (Fuchs et al., 1997). Classical

cross protection has been known since 1929, but it has not been extensively used due to the difficulties of obtaining useful mild strains and the fear that the live viruses could spread to other crops or mutate into severe forms (Fuchs et al., 1997). Cross protection was used in melon plants in California against ZYMV by using a weak strain of ZYMV (Perring et al., 1995) to produce economically significant virus protection. There has been no report on cross protection of PRSV-W and ZYMV in watermelon. Cross protection of papaya against PRSV was used in Taiwan (Wang et al., 1987). Cross protection of squash with the weak strain of ZYMV has been commercialized in Hawaii (Cho et al., 1992).

Plants can also be cross protected against a virus by being genetically modified to synthesize the coat protein of the virus (Pappu et al., 1995; Namba et al., 1992; Quemada et al., 1990a and 1990b). It involves cloning the coat protein or replicase genes of the virus, inserting the clonal constructs into plant cells using *Agrobacterium tumefaciens* and regenerating plants from transformed cells. Insertion of a virus gene into plants modifies the structure and blocks replication at critical points in the virus replication cycle (Shukla et al.., 1994). Coat protein-mediated protection to viruses has been used successfully for numerous viruses of different genera (Beachy et al., 1990). Stark and Beachy (1989) were the first to investigate protection against potyviruses and produced transgenic tobacco plants containing the coat protein gene of *Soybean mosaic virus* (SbMV). Transgenic yellow squash lines have been developed that express coat protein gene constructs for *Cucumber mosaic virus* (CMV), ZYMV, and WMV (Fuchs et al. 1998; Grumet et al. 1995), and transgenic yellow squash cultivars are currently available. No transgenic virus resistant watermelon cultivars are available. Coat protein-mediated virus protection using genetic engineering may provide additional sources of resistance. That resistance is useful when development of virus resistant cultivars using classical breeding is limited due to a lack of resistance genes. However, concerns about the safety of transgenic crops are a significant market factor, with transgenic cultivars being ineligible for labeling as organically grown. In addition, genetically engineered seed is expensive and access must be tightly controlled. Thus, seed companies and plant breeders continue to pursue virus resistance through traditional breeding methods using genetic resistance.

PRSV-W has great economic importance because of its destructiveness (Provvidenti, 1993). PRSV-W has been described as one of the five most important viruses in field-grown vegetables (Tomlinson,

1987). Type W isolates have been reported in cucurbits in many areas including the USA, Mexico, the Caribbean islands, Australia, Germany, France, Italy, India, countries of the Middle East, and South America (Murant and Harrison, 1984; Purcifull et al., 1984). PRSV-W causes significant yield reduction in watermelon, melon, cucumber, and squash (Lecoq et al., 1998; Gibb et al., 1994). In Florida, yield loss to the virus was up to 100% in summer squash (*Cucurbita pepo*) and watermelon (Sowell and Demski, 1969) with early infections of PRSV-W.

Resistance to PRSV-W has been identified in cucumber (*Cucumis sativus*), melon (*Cucumis melo*), and squash (*Cucurbita* spp.) (Provvidenti, 1993). There are two major sources of potyvirus resistance in cucumber, the Dutch hybrid 'Dina' and the Chinese cultivar 'Taichung Mou Gua'. Both 'Dina' and TMG-1 (a single-plant selection from TMG) are resistant to PRSV and PRSV-W as well as WMV and ZYMV (Provvidenti, 1985). Resistance to PRSV-W in TMG-1 is conferred by a single dominant gene (Wai and Grumet, 1995). The genetics of PRSV and PRSV-W resistance in 'Dina' is unclear. A recessive gene for PRSV-W resistance was found in the cultivar 'Surinam Local'. Resistance to PRSV-W in 'Surinam Local' was inherited as a monogenic recessive (Wang et al., 1984). Provvidenti and Robinson (1977) reported resistance to PRSV in some accessions of *Cucumis metuliferus* (also known as the horned cucumber or jelly melon) and governed by a single dominant gene. Those resistant to PRSV were also found to be resistant to PRSV-W (Provvidenti and Gonsalves, 1982).

Pitrat and Lecoq (1983) reported resistance to PRSV-W in the melon accessions PI 180280 and PI 180283, and showed that resistance is controlled by a single dominant gene. The resistances from these two sources appeared to be allelic. Resistance to PRSV-W in the acid melon accession PI 414723 from India was also reported, and its inheritance was controlled by a single dominant gene. It is not known whether PRSV-W resistance from PI 414723 is allelic to the other PRSV-W resistance genes identified in melon. This PI was also reported resistant to PRSV, WMV and ZYMV (Pitrat and Leqoc, 1984; Gilbert et al., 1994; Anagnostou et al., 2000).

Resistance to PRSV-W has also been reported in squash. However, resistance of PRSV-W like ZYMV was found only outside *Cucurbita pepo*. A few accessions of *Cucurbita maxima* have been reported resistant to PRSV-W (Provvidenti, 1982; Maluf et al., 1997; Herrington et al., 1991). *Cucurbita*

ecuadorensis was found resistant to *Cucumber mosaic virus* (CMV), PRSV-W, WMV, ZYMV and squash mosaic virus (SMV). Two accessions of *Cucurbita moschata*, 'Nigerian Local' and 'Menina' have been used widely as a source of virus resistance. 'Nigerian Local' is resistant to CMV, WMV, PRSV-W, and ZYMV (Kyle, 1995), and 'Menina' has been shown to be resistant to WMV and ZYMV (Gilbert-Albertini et al., 1993). Resistance to PRSV-W is controlled by a single recessive gene in *C. moschata* (Bolanos-Herrera, 1994). In *C. maxima*, resistance is multigenic, with three genes providing partial dominance (Maluf et al., 1997). Tasaki and Dusi (1990) reported that resistance was controlled by a single dominant gene in crosses between C. *ecuadorensis* and *C. maxima* 'Kurokawa Delicious'. However, crosses between *C. ecuadorensis* and *C. maxima* 'Queensland Blue' showed that resistance to PRSV-W was polygenic, with additive effects predominant (Herrington et al., 1989).

Zucchini yellow mosaic virus is a relatively new virus in watermelon production areas (Nameth et al., 1985). ZYMV infects all the agriculturally important species of the Cucurbitaceae (Provvidenti, 1991), causing significant yield reduction (Nameth et al., 1985). The virus was first reported on squash (*Cucurbita pepo*) in northern Italy in 1981 (Lisa and Dellavalle 1981; Lisa and Lecoq 1984). Within a decade, ZYMV spread to the major cucurbit-producing regions worldwide. The severity of infection depends on the age of plants at infection, the strain of ZYMV, and the environment, particularly temperature (Desbiez and Lecoq, 1997).

ZYMV is spread in a non-persistent manner by a number of aphid species, and easily transmitted mechanically. In areas where cucurbits are not grown continuously, the virus overwinters on wild species. Natural infection appears to be limited to members of the Cucurbitaceae, but members of 11 families of dicotyledons are considered diagnostic hosts. At least 25 strains of ZYMV have been identified (Desbiez and Lecoq, 1997). Provvidenti et al. (1984) reported the occurrence of Connecticut (CT) and Florida (FL) strains of ZYMV, with the FL strain occurring more widely in the United States.

Symptoms of severe ZYMV infection in cucurbits include yellow mosaic, stunting, leaf blistering, leaf size reduction, and fruit remaining small, developing knobby areas, greatly malformed, and mottled (Provvidenti, 1996). ZYMV cause important yield reductions in watermelon, squash, melon, cucumber and other cultivated cucurbits (Nameth et al., 1985).

The watermelon germplasm collection has been screened for resistance to ZYMV, and PI accessions were identified (Boyhan et al. 1992; Provvidenti, 1991) with significant levels of resistance. Provvidenti (1991) reported ZYMV resistance in four landraces in four PI accessions from Zimbabwe (PI 482322, PI 482299, PI 482261, and PI 482308). That resistance was specific to the Florida strain of ZYMV (ZYMV-FL) because those accessions were not resistant to the Connecticut strain or the Egyptian strain. Some accessions of the Nigerian Egusi watermelon (PI 494528 and PI 494532) were reported resistant to ZYMV, and the resistance was not viral strain specific (Provvidenti, 1986a). However, that resistance was temperature dependent, usually expressed in warm or hot climates. Resistance in PI 482261 was conferred by a single recessive gene, *zym* (Provvidenti, 1991). Watermelon germplasm was also screened for ZYMV resistance by Boyhan et al. (1992) who tested 153 PI accessions, breeding lines, and commercial cultivars. They found new sources of resistance to ZYMV in PI 595203 (*Citrullus lanatus* var. *lanatus*), formerly referred as Egun, as well as in PI 386026 and PI 386025. They also confirmed the resistance of PI 482261 and PI 494528.

Sources of resistance to ZYMV have been found in cucumber (*Cucumis sativus*), melon (*Cucumis melo*), and squash (*Cucurbita* spp.). ZYMV resistance is controlled by a single recessive gene in cucumber (Kabelka et al., 1997), a single dominant gene in melon (Pitrat and Lecoq, 1984), and a single dominant gene in squash (Munger and Provvidenti, 1987; Paris et al., 1988; Gilbert-Albertini et al., 1993; Brown et al., 2003).

Watermelon mosaic virus is one of the most destructive viruses affecting watermelon production worldwide and in the United States. The virus was first described by Webb and Scott (1965). WMV naturally infects members of Cucurbitaceae, Chenopodiaceae, Malvaceae and Leguminosae families (Shukla 1994). Resistance to WMV in *Citrullus lanatus* and in *C. colocynthis* have been reported. Resistance to WMV in watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai) has been reported to vary with virus strain. In India, 59 watermelon cultivars were found to be resistant to WMV (Bhargava and Bhargava, 1976). However, Sowell and Demski (1969) showed that all 59 cultivars tested were susceptible. Three PI accessions (PI 248178, PI 249010, and PI 255137) were reported free of symptoms in a field test in Florida (Adlerz and Crall, 1967). 'Egun' (*C. lanatus*) (Webb, 1977) and some Egusi

accessions (PI 494528 and PI 494532) were also reported resistant to WMV. Gillaspie and Wright (1993) evaluated a total of 670 *Citrullus* species for resistance to WMV. Selections from 10 *C. lanatus* accessions (PI 189316, PI 189317, and PI 189318 from Zaire; PI 244018, PI 244019, and PI 255137 from South Africa; PI 164708 from India; PI 306782 from Nigeria; and PI 494529 and 'Egun', were reported resistant in both field and greenhouse tests. Five *C. colocynthis* PI accessions (PI 386016, PI 386024, PI 386025, and PI 386026 from Iran, and PI 388770 from Morocco) had some resistance in both field and greenhouse tests (Gillaspie and Wright 1993). *C. colocynthis* can be intercrossed with *C. lanatus*, and is a useful source of resistance. A major problem with *C. colocynthis* is that it is not useful commercially, and the flesh is tasteless (Munger et al., 1984).

Cucumber mosaic virus infects numerous plant species and is one of the most important viruses affecting vegetables worldwide (Palukaitis et al., 1992). CMV resistance has been reported in watermelon. Provvidenti (1986a) tested six *C. colocynthis* PI accessions, and all of them were resistant to CMV. These were PI 494527, PI 494528, PI 494529, PI 494530, PI 494531, and PI 494532.

There have been no reports of screening for resistance to other viruses in watermelon. Such viruses include *Melon rugose mosaic virus*, which was first described and named by Jones et al. (1986); *Melon necrotic spot virus* (Avegelis, 1989); *Tobacco ringspot virus* (Shepherd and Struble, 1956); and *Watermelon curly mottle virus* (Brown and Nelson, 1989).

Watermelon has not been screened extensively for resistance to PRSV-W although some preliminary research has been done. Munger et al. (1984) screened six PI accessions for PRSV-W resistance by using an unidentified isolate of PRSV-W. Their preliminary results showed some genetic differences among seven watermelon PI accessions. Twenty watermelon cultivars and hybrids were screened with the most aggressive Brazilian isolate of PRSV-W (Hojo et al. 1991a). BT-8501, a wild, bitter-fruited watermelon from Africa was identified as resistant (Hojo et al. 1991b). Additionally, there may be field tolerance available in some landraces of watermelon (Provvidenti, 1986a). The inheritance of PRSV-W in watermelon has not been determined.

The watermelon germplasm collection at the Plant Genetic Resources Unit in Griffin, Georgia has more than 1,600 watermelon PI accessions. Considerable numbers of PIs were added to watermelon

germplasm collection since part of the collection was first screened for ZYMV in 1991. Also, recent seed increases made more PI accessions available for researchers to evaluate. So far, 221 PI accessions, breeding lines and commercial cultivars have been screened for ZYMV resistance in the studies conducted by Provvidenti (1991) and Boyhan et al. (1992), consisting of 14% of the watermelon germplasm collection. It is a strong possibility that higher resistance to ZYMV can be identified by screening the other 86% of the collection. The identification of additional sources of resistance to ZYMV and incorporation of this resistance into commercial cultivars would be desirable.

The objectives of this study was 1) to screen the USDA watermelon germplasm collection along with available watermelon cultivars for PRSV-W resistance; 2) to verify the disease rating for the most resistant and most susceptible accessions; and 3) to determine the genetic control of PRSV-W resistance; 4) to screen the U.S.D.A. watermelon germplasm collection along with available watermelon cultivars to identify additional sources of resistance to ZYMV.

Chapter One

Screening the Watermelon Germplasm Collection for Resistance to *Papaya Ringspot Virus Type-W*

(In the format appropriate for submission to the Journal of the American Society for Horticultural Science, published in Crop Science in 2002, Crop Sci. 42: 1324-1330.)

For: Journal of ASHS

Breeding and Genetics

Screening the Watermelon Germplasm Collection for Resistance to *Papaya Ringspot Virus Type-W*

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Additional index words. Cucurbitaceae, *Citrullus lanatus*, mosaic, disease resistance, selection methods, pathology, vegetable breeding

Received for publication _____. The research reported herein was funded in part by the North Carolina Agricultural Research Service. Use of trade names in this publication does not imply endorsement by the NCARS or the products named, or criticism of similar ones not mentioned.

Graduate research assistants, assistant professor, and professor, respectively. The authors gratefully acknowledge the technical assistance of Tammy L. Ellington.

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Screening the Watermelon Germplasm Collection for Resistance to *Papaya Ringspot Virus Type-W*

Additional index words. Cucurbitaceae, Citrullus lanatus, mosaic, pathology, vegetable breeding

Abstract

Papaya ringspot virus watermelon strain (PRSV-W), formerly *watermelon mosaic virus-1*, infects all the agriculturally important species of the Cucurbitaceae and is a major disease of watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai). The objectives of this study were 1) to screen the USDA watermelon germplasm collection for PRSV-W resistance; 2) to verify the disease rating for the most resistant and most susceptible accessions; and 3) to determine the number of escapes based on the retest of the germplasm screening test. The experiment was a randomized complete block with five replications and 1275 accessions. 'Charleston Gray' susceptible checks were used to verify that the PRSV-W inoculum was virulent. Enzyme-linked immunosorbent assay (ELISA) was performed after the last rating to determine whether the virus was in the plant tissue. PI accessions with the highest resistance to PRSV-W that also had resistance to other watermelon viruses (ZYMV, *Zucchini yellow mosaic virus* or WMV, *Watermelon mosaic virus*, formerly *Watermelon mosaic virus-2*) were PI 244018, PI 244019, PI 255137, and PI 482299. The first retest of the most resistant 21 PI accessions showed that there were some escapes that were not resistant to PRSV-W. Of the 21 PI accessions in the first retest, seven PI accessions were identified for further testing. Of the 60 resistant PI accessions in the final retest, eight had resistance with a rating of 3.6 or less for the best, average and maximum ratings:, PI 244017, PI 244019, PI 482342, PI 482318, PI 485583, PI 482379, PI 595203, and PI 244018.

Watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai) is a major crop in the southern United States. The most important virus diseases of watermelon in the United States are *Papaya ringspot virus*-

watermelon strain (PRSV-W, formerly *Watermelon mosaic virus-1*), *Watermelon mosaic virus* (WMV, formerly *Watermelon mosaic virus-2*), and *Zucchini yellow mosaic virus* (ZYMV) (Adlerz and Crall, 1967). Virus diseases are destructive to the watermelon crop and are difficult to control (Sherf and Macnab, 1986).

Major virus control strategies include the use of insecticides to eliminate virus vectors, herbicides to remove alternate hosts for the virus, and genetic resistance (Provvidenti, 1993), which is often pathogen-specific (Grumet, 1989). Of those controls, the most economical method is genetic resistance. Virus resistance may also be accomplished through virus coat proteins transferred into existing cultivars (Namba et al., 1992; Quemada et al., 1990a), or by screening of germplasm collections. Either method might be used successfully in watermelon. The watermelon germplasm collection has been screened for resistance to several virus diseases. Boyhan et al. (1992) identified PI accessions resistant to ZYMV, and Gillaspie and Wright (1993) identified PI accessions resistant to WMV. Researchers have screened other cucurbit species for resistance to PRSV-W and the inheritance of the resistance has been determined. Provvidenti and Gonsalves (1982) found in *Cucumis metuliferus* that accessions resistant to WMV were also resistant to PRSV and that the resistance was controlled by a single dominant gene.

PRSV-W virus infects all the agriculturally important species of the Cucurbitaceae (Provvidenti, 1993). PRSV-W was known as watermelon mosaic virus-1 until it was shown to be a strain of *Papaya ringspot virus* (Provvidenti, 1993). This virus is transmitted in a non-persistent manner by 24 species of aphid in 15 genera. Resistance to the virus has been identified in cucumber (*Cucumis sativus*), melon (*Cucumis melo*), squash (*Cucurbita* spp.), and gourds (*Lagenaria* spp., and *Luffa* spp.) (Provvidenti, 1993).

Previous research has demonstrated that screening watermelon for resistance to PRSV-W should be effective. Munger et al. (1984) used an unidentified isolate of PRSV-W to find genetic differences among seven watermelon PI accessions. Hojo et al. (1991a) used an aggressive Brazilian isolate, Ab-081, to screen watermelon for virus resistance. They identified one resistant accession, BT-8501, a wild, bitter-fruited watermelon from Africa (Hojo et al., 1991b). Additionally, there may be field tolerance available in some land races of watermelon (Provvidenti, 1986b).

The objectives of this study were 1) to screen the USDA watermelon germplasm collection for PRSV-W resistance; 2) to verify the disease rating for the most resistant and most susceptible accessions; and 3) to determine the number of escapes based on the retest of the germplasm screening test.

Material and Methods

Germplasm evaluated

Three large experiments were performed: a germplasm screening, an early retest of the screening results, and a final retest. All experiments were performed in the North Carolina State University plant pathology greenhouses. Greenhouse temperatures ranged 23 to 43°C (day) and 12 to 24°C (night). The virus isolate was obtained from D.E. Purcifull, University of Florida, Gainesville. The PRSV-W isolate used was 2052 described by Baker et al. (1991) and was maintained on 'Gray Zucchini' squash (*Cucurbita pepo* L.) from Seminis Vegetable Seeds (Woodland, CA). All *Citrullus* Plant Introduction (PI) accessions were obtained from the Southern Regional Plant Introduction Station at Griffin, Georgia. PI accessions originated in 68 different countries, with 46 countries having fewer than 10 accessions each. Countries with the most accessions in the collection of 1275 were Turkey (296), Yugoslavia (163), Zimbabwe (122), India (120), Spain (71), Zambia (55), South Africa (36), Syria (28), Iran (27), China (26), and Nigeria (23).

Inoculation

Inoculum was produced by grinding infected Gray Zucchini squash leaves using mortar and pestle in 0.02 M phosphate buffer, pH 7.0. Leaf to buffer ratio was 1:5 (1 g infected leaf to 5 ml buffer). The inoculation procedure was the same for increasing on squash and for screening watermelon. Inoculation consisted of dusting one leaf on each three-week-old plant with an 800-mesh carborundum, then applying the inoculum to the leaf with a pestle which was rotated in a circular motion eight to ten times as if painting the leaf with inoculum. After inoculation, carborundum was rinsed off the leaves to improve light interception, and the plants were maintained in aphid-proof cages. All Gray Zucchini squash plants were seeded in metromix 200 (Scotts-Sierra Horticultural Products Company, Marysville, OH) in 160 mm diameter (1550 ml volume) clay pots. Plants were fertilized weekly with 150 $mg \cdot kg^{-1}$ Peters Professional 20-20-20 N-P-K (Scotts-Sierra Horticultural Products Company, Marysville, OH).

Germplasm screening

The germplasm screening was a randomized complete block with five replications of 1275 accessions. Each plot was a 100 x 100 mm square pot (600 ml volume) planted with two seeds and thinned to one plant before inoculation. In addition to the accessions tested, there were 50 check plants per replication of 'Charleston Gray' that were inoculated with the virus, and 50 plants of Charleston Gray that were not inoculated. The inoculated checks served as verification of viral infection and the uninoculated checks served as an indicator of other disease in the greenhouse that might confound symptom expression.

Traits evaluated

To screen large numbers of PI accessions for resistance to PRSV-W, a rating system was used that took into account the different growth habits and leaf morphologies of the different accessions. The rating system was general enough to allow for the differences in the PI accessions but specific enough to distinguish resistant plants. Plants were inoculated at the first true leaf stage, and rated weekly for six weeks on a scale of 0 to 9 on the basis of severity of viral symptoms, where 0=none, 1-2=trace, 3-4=slight, 5-6=moderate, 7-8=severe, and 9=plant dead. After the second rating, plants which had not emerged at the time of inoculation and those plants which were inoculated and had a rating under 4 were re-inoculated to reduce the number of escapes. After the sixth rating, all plants that were not dead were tested using enzyme-linked immunosorbent assay (ELISA, Agdia Incorporated, Elkhart, IN) to determine if there was virus present in the leaf tissue. Tissue used for testing was taken from a sample of the top five leaves of the plant. Those plants which did not have virus in their system and which had a low rating were considered resistant.

Originally, we used *Chenopodium amaranticolor* to check inoculation efficacy. However, that was not a reliable indicator, so checks of Charleston Gray were inoculated and observed for viral symptoms. In the reinoculation stage, three check plants that were the same age as the test plants to be reinoculated and three two-week-old checks were inoculated periodically during the reinoculation to assure that the inoculum was virulent. All PI accessions were maintained in a screened greenhouse which contained no other cucurbits and in which there were no other viral experiments being performed.

Early Retest

An early retest was performed after the completion of the first two replications of the germplasm screening to determine variability within the resistant accessions. This also provided a method for determining the number of 'escapes' and errors in the germplasm screening before continuing with the next replications. Results were used to plan the next studies, and to begin seed increases of cultigens having resistance to PRSV-W. The early retest was performed using 1 replication of 21 plants per accession from the 21 most resistant accessions along with the susceptible check, Charleston Gray. Inoculation and rating procedures were the same as for the germplasm screening.

Final Retest

A final retest was performed after the completion of the germplasm screening to verify the reaction of the most resistant and susceptible accessions. We were also interested in measuring the variability over replications. The experiment was a randomized complete block with 4 replications of 72 cultigens along with 2 susceptible checks (Charleston Gray and 'Crimson Sweet'). Plots consisted of two 100 x 100 mm square pots (600 ml volume). Extra pots of each accession were planted to assure that all plots would have the same number of plants even with differences in germination. The cultigens were inoculated with four isolates of PRSV-W, which were 2052, W-1A, 1870, and 2040. Plants were inoculated by using the rub method at the first true leaf stage, and rated three times weekly on a 0 to 9 scale starting two weeks after inoculation.

Data analysis

Data were summarized as the average, the maximum, and the best of the six ratings. The best rating was the one with the greatest range over the 1275 cultigens, which was rating 3 in this experiment. Data were analyzed using the MEANS, ANOVA and GLM procedures of the SAS statistical package (SAS Institute, Cary, NC). Data were based on ratings from single-plant plots, and each rating date was analyzed separately.

Results and Discussion

Germplasm screening

Not all of the 1275 accessions germinated in all five replications, and data were obtained for 1248 accessions. The complete dataset was submitted to the Germplasm Resources Information Network (http://www.ars-grin.gov/) for those interested in particular cultigens and also listed in appendix table 1. The most resistant and most susceptible cultigens are presented here, along with checks and cultigens included in the retests (Table 1.1). The ANOVA indicated that there were highly significant differences (P=0.01) among accessions for all rating dates (data not shown). Since the best and average ratings were highly correlated (r=0.90), and the maximum rating had a smaller F ratio than the other ratings, only the best rating was given in Table 1.1 to save space. In a study such as this, where most of the 1275 accessions were susceptible and had ratings of 8 to 9, there was the possibility that the few resistant accessions identified were overwhelmed in the analysis of variance by the large number of susceptible accessions. In order to evaluate the importance of that effect, the ANOVA was rerun using only the most resistant 52 and the most susceptible 52 accessions. That effect was large in this study, with the F ratio changing from 1.5 for the 1248 cultigens to 9.3 for the 104 cultigens. Therefore, both analyses showed significant differences among PI accessions, but the smaller data set had a larger accession F ratio due to the smaller variances for replication and error, and the larger accession variance.

The criteria for identifying resistance was to use the best, average, and maximum ratings, along with ELISA results. There were 49 PI accessions that had a maximum rating less than 6.0, although it should be noted that all plants infected with the virus eventually died. That indicates that there is no immunity to the isolate used in this study. This contrasts with ELISA results, where we identified accessions that did not have virus in their tissues at the time of testing. This could be due to errors in the ELISA tests, but all positive and negative controls for all ELISA tests performed were accurate. It should be noted that no observations of watermelon PI accessions were taken beyond the 6^{th} rating of virus symptoms. This study reports resistance to PRSV-W most virulent isolate 2052 (collected in Florida). However, resistant accessions may not be resistant to other isolates in Florida or other regions where PRSV-W is found.

Our results paralleled that of previous researchers in that variation for virus resistance was identified in the watermelon germplasm collection. Boyhan et al. (1992) working with ZYMV, and Gillaspie and Wright (1993) working with WMV were able to identify resistant accessions in their watermelon research. PI 482299, PI 482261, PI 595203, and PI 255137 found to be resistant to ZYMV also had some resistance in this study to PRSV-W. Other accessions reported to have resistance to ZYMV were not tested in this study. One accession, PI 595202, reported to have ZYMV resistance did not show resistance to PRSV-W in this study. PI 244018 and PI 244019 found to be resistant to WMV by Gillaspie and Wright (1993), showed resistance to PRSV-W. Other accessions that were found to be resistant to WMV (PI 189316, PI 189317, and PI 248178) did not have resistance to PRSV-W. Provvidenti and Gonsalves (1982) worked with *Cucumis metuliferus* and found that the accessions they identified as resistant to WMV were also resistant to PRSV. This was the case for some of the accessions screened in this study.

Gillaspie and Wright (1993) found there was plants that tested negative for virus in ELISA that later tested positive. This is consistent with what we found. Thus, even though there were plants that tested negative for virus with ELISA, all plants eventually showed symptoms of PRSV-W and died. The issue of escapes should not be underestimated. Studies for resistance to WMV and ZYMV found, during retests, that some accessions which were initially rated resistant were actually just escapes. It is likely that some of the accessions reported to be resistant here are escapes.

The susceptible check used for this study was Charleston Gray, a widely available cultivar. However, we identified accessions having more susceptibility to PRSV-W. Accessions would make excellent susceptible checks because they have high germination rates, and best ratings of 9.0 compared to Charleston Gray, which had a best rating of 8.2 (Table 1.1). Any of the following accessions could be used as susceptible checks: PI 379253, PI 512383, PI 169270, PI 178877, PI 169244, PI 560016, PI 368495, PI 357727, PI 381696, PI 502318, PI 176485, PI 176921, PI 368497, PI 368515, PI 379245, PI 178873, PI 279461, PI 176490, PI 500309, PI 508442, PI 357690, PI 357735, PI 278027, PI 507859, PI 195928, PI 532817, PI 176499, PI 500332, PI 512358, PI 379246, PI 357675, PI 512391, PI 512359, PI 296337, PI 169283, PI 179661, PI 295850, PI 179662, PI 169252, PI 183399, PI 357728, PI 357692, PI 512407, PI 169258, PI 234603, PI 357698, PI 357736, PI 169245, PI 490382, PI 378613, and PI 296342.

The PI accessions with the most resistance along with complete data (missing in no more than one replication) were: PI 244017, PI 244018, PI 482342, PI 234287, and PI 482303 (Table 1.2). The PI accessions that showed resistance to other watermelon viruses in addition to resistance to PRSV-W in this study were PI 244018, PI 244019, PI 482226, PI 595203, PI 255137 and PI 482299.

Early Retest

The retest of the most resistant 21 PI resistant accessions (along with Charleston Gray check) based on data from the first two replications showed that there were some escapes that were not resistant to PRSV-W (Table 1.3). Of the 462 plants tested, 58 plants representing 15 PI accessions were resistant to PRSV-W. Of those, 9 plants from 5 accessions had a final rating under 9.0. Of the 21 PI accessions, the seven PI accessions having 4 or more plants out of 21 resistant were PI 164687, PI 244017, PI 244018, PI 482303, PI 482319, and PI 485583. PI 482319 had 2 plants alive at the time of the final rating in both the early retest and the germplasm screening. One accession, PI 244018, had 14 plants designated resistant, with 3 plants alive at the final rating. Also, it was reported resistant to WMV (Gillaspie and Wright, 1993). Another accession, PI 482299, had 2 plants resistant and was reported resistant to ZYMV (Provvidenti, 1991).

Three accessions considered to be resistant in the germplasm screening, PI 482254, PI 482317, and PI 505604, were mostly susceptible in the early retest with only one plant out of 21 per accession that showed resistance. It is likely that these PI accessions were escapes, especially since data for the test came from only the first two replications of the screening study. The remaining six PI accessions with no plants that met the criteria for resistance were probably also escapes (Table 1.3).

Final Retest

The final retest was conducted at the completion of the germplasm screening. The final retest results paralleled those of the early retest results, in that there were escapes that were not resistant to PRSV-W (Table 1.4). Of the 60 resistant PI accessions in the final retest, eight had resistance with a rating of 3.6 or less for the best, average and maximum ratings: PI 244019, PI 244017, PI 482342, PI 482318, PI 485583, PI 482379, PI 595203, and PI 244018. PI 244017 was given the highest resistant rating in both the

germplasm screening and the final retest experiments. The 12 susceptible PI accessions had about the same level of susceptibility to PRSV-W as the Charleston Gray and Crimson Sweet checks.

Since the seed supply of many PI accessions was increased by open pollination or by sib pollination, there should be heterogeneity and heterozygosity within an accession. Thus, if resistance was quantitatively inherited, and accessions were segregating for resistance, the most resistant accession found in this study would not necessarily have the highest level of resistance possible. Resistance might be improved by intercrossing the most resistant accessions, or by crossing accessions with high vs. moderate resistance.

Further research is needed to determine whether other isolates of PRSV-W from different geographic regions react the same on the resistant and susceptible cultigens from this experiment. Additional research is needed to determine the inheritance of resistance to PRSV-W in the cultigens identified. The accessions with highest resistance to PRSV-W should be used to develop inbreds with the highest possible resistance for use in developing resistant cultivars.

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Table 1.1. Best rating and number of replications of data (out of 5) for 1248 watermelon accessions inoculated with PRSV-W.[+]

Rank	Accession or cultivar	Country of origin	Best rating
Resistant			
1	PI 278005	Turkey	3.0
2	PI 277972	Turkey	3.0
3	PI 278009	Turkey	3.0
4	PI 244017	S. Africa	3.4
5	PI 174104	Turkey	3.5
6	PI 164665	India	3.5
7	PI 164737	India	4.0
8	PI 244019	S. Africa	4.0
9	PI 244018	S. Africa	4.0
10	PI 278008	Turkey	4.0
11	PI 314655	Soviet Union	4.0
12	PI 277989	Turkey	4.0
13	PI 532667	Swaziland	4.0
14	PI 357752	Yugoslavia	4.0
15	PI 346082	Afghanistan	4.0
16	PI 482342	Zimbabwe	4.4
17	PI 277990	Turkey	4.5

(continued next page)

Table 1.1. (continued)

Rank	Accession or cultivar	Country of origin	Best rating
18	PI 319212	Egypt	4.5
19	PI 234287	Portugal	4.8
20	PI 482303	Zimbabwe	4.8
21	PI 275628	Pakistan	5.0
22	PI 482261	Zimbabwe	5.0
23	PI 512364	Spain	5.0
24	PI 254742	Senegal	5.0
25	PI 177328	Turkey	5.0
26	PI 176489	Turkey	5.0
27	PI 271132	Tunisia	5.0
28	PI 485583	Botswana	5.2
29	PI 525086	Egypt	5.2
30	PI 195562	Ethiopia	5.3
31	PI 482322	Zimbabwe	5.3
32	PI 169232	Turkey	5.3
33	PI 169241	Turkey	5.3
34	PI 482318	Zimbabwe	5.4
35	PI 255137	S. Africa	5.5
36	PI 525088	Egypt	5.6

(continued next page)

Table 1.1. (continued)

Rank	Accession or cultivar	Country of origin	Best rating
37	PI 595203	US, GA	5.6
38	PI 278058	Turkey	5.6
39	PI 482379	Zimbabwe	5.7
40	PI 345543	Soviet Union	5.7
41	PI 172803	Turkey	5.7
42	PI 278026	Turkey	5.7
43	PI 169238	Turkey	5.7
44	PI 271986	Somalia	5.7
45	PI 482315	Zimbabwe	5.8
46	PI 534592	Syria	5.8
47	PI 526235	Zimbabwe	5.8
48	PI 482299	Zimbabwe	5.8
49	PI 482305	Zimbabwe	5.8
50	PI 482269	Zimbabwe	5.8
51	PI 482312	Zimbabwe	5.8
52	PI 246559	Senegal	5.8
Checks and Accessions Included in Retests			
54	PI 307609	Nigeria	6.0
55	PI 175663	Turkey	6.0

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Table 1.1. (continued)

Rank	Accession or cultivar	Country of origin	Best rating
69	PI 482309	Zimbabwe	6.2
74	PI 357679	Yugoslavia	6.3
81	PI 534584	Syria	6.4
89	PI 502319	Uzbekistan	6.5
108	PI 482319	Zimbabwe	6.6
109	PI 537271	Pakistan	6.6
110	PI 512406	Spain	6.6
140	PI 169243	Turkey	6.8
159	PI 536450	Maldives	6.8
188	PI 490376	Mali	7.0
189	PI 254624	Sudan	7.0
191	PI 164687	India	7.0
193	PI 482254	Zimbabwe	7.0
194	PI 482317	Zimbabwe	7.0
195	PI 174105	Turkey	7.0
208	Grif 1729	China	7.0
257	PI 177329	Turkey	7.2
338	PI 163203	India	7.4
358	Grif 1730	China	7.4

(continued next page)

Table 1.1. (continued)

Rank	Accession or cultivar	Country of origin	Best rating
400	PI 378617	Zaire	7.6
402	Grif 1733	China	7.6
450	PI 505604	Zambia	7.8
487	Grif 1732	China	7.8
558	Grif 5596	India	7.8
645	Grif 12335	China	8.0
650	Grif 12336	China	8.0
732	Grif 5597	India	8.0
781	Grif 5598	India	8.0
875	Charleston Gray	Check	8.2
915	Grif 1734	China	8.4
923	Grif 5599	India	8.4
1012	Grif 1731	China	8.8
Susceptible			
1106	PI 379245	Yugoslavia	9.0
1107	PI 178873	Turkey	9.0
1108	PI 279461	Japan	9.0
1109	PI 176490	Turkey	9.0
1110	PI 500309	Zambia	9.0

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Table 1.1. (continued)

Rank	Accession or cultivar	Country of origin	Best rating
1112	PI 508442	S.Korea	9.0
1117	Grif 1728	China	9.0
1124	PI 357690	Yugoslavia	9.0
1128	PI 357735	Yugoslavia	9.0
1131	PI 278027	Turkey	9.0
1149	PI 532817	China	9.0
1154	PI 176499	Turkey	9.0
1155	PI 500332	Zambia	9.0
1208	PI 254428	Lebanon	9.0
1209	PI 169245	Turkey	9.0
1210	PI 490382	Mali	9.0
1211	PI 378613	Zaire	9.0
1212	PI 211852	Iran	9.0
1213	PI 277991	Turkey	9.0
1214	PI 288522	India	9.0
1215	PI 381713	India	9.0
1216	PI 172798	Turkey	9.0
1217	PI 183217	Egypt	9.0
1218	PI 296342	S. Africa	9.0

(continued next page)

Table 1.1. (continued)

Rank	Accession or cultivar	Country of origin	Best rating
1219	PI 357737	Yugoslavia	9.0
1220	PI 278018	Turkey	9.0
1241	PI 357680	Yugoslavia	9.0
1242	PI 279462	Japan	9.0
1243	PI 169263	Turkey	9.0
1244	PI 177323	Turkey	9.0
1245	PI 278003	Turkey	9.0
1246	PI 278038	Turkey	9.0
1247	PI 368524	Yugoslavia	9.0
1248	PI 532664	Swaziland	9.0
LSD (5%)			1.8

+ Some countries listed as the origin of some accessions no longer exist as political units (Czechoslovakia, Soviet Union, Yugoslavia). Rank indicates the ranking of the cultigen for resistance to PRSV-W, based on best rating.

Table 1.2. Mean resistance ratings of the five PI accessions of watermelon (with 'Charleston Gray') having the highest resistance to PRSV-W and complete data (missing in no more than one replication).+

Rank	Accession or cultivar	Country of origin	Virus rating Best	Ave.	Max.	Maximum rating Rp1	Rp2	Rp3	Rp4	Rp5
1	PI 244017	S. Africa	3.4	4.7	6.8	5.0-	9.0	6.0	9.0	5.0+
2	PI 244018	S. Africa	4.0	5.5	8.0	5.0	9.0	9.0	9.0	-
3	PI 482342	Zimbabwe	4.4	5.3	7.2	9.0	9.0	9.0	5.0+	4.0+
4	PI 234287	Portugal	4.8	5.7	8.0	5.0	9.0	-	9.0	9.0
5	PI 482303	Zimbabwe	4.8	5.7	8.6	5.0-	9.0	9.0	9.0	9.0
6	Charleston Gray (check)		8.2	8.0	8.9	8.3	7.0	9.0	9.0	8.3
LSD (5%)			1.8	1.1	0.6	-	-	-	-	-

+ Plants were rated on a scale of 0 to 9 on the basis of severity of viral symptoms, where 0=none, 1-2=trace, 3-4=slight, 5-6=moderate, 7-8=severe, and 9=plant dead. Best is the average of third rating for the 5 replications. Maximum is the average of six rating for all of the replications. Average is the overall average of all the ratings for all the replications. Final rating refers to the 6th of six ratings for each replication. - and + indicate results from ELISA testing and refer to no virus detected in tissue and virus detected in tissue, respectively. Rank indicates the ranking of the cultigen for resistance to PRSV-W, based on best rating (as well as average and maximum ratings).

Table 1.3. Mean resistance ratings of 21 plants of 22 watermelon PI accessions found resistant to PRSV-W in first and second replication of screening, including Charleston Gray as the check.[+]

Accession name	Average rating	Maximum rating	Rating date 1	2	3	4	5	6
PI 244018	6.1	8.5	5.0	5.3	4.7	5.3	7.8	8.4
PI 485583	7.1	9.0	5.7	5.7	6.3	7.1	8.6	9.0
PI 482303	7.2	8.9	5.5	6.1	7.0	7.7	8.0	8.9
PI 244017	7.3	8.8	5.5	6.3	7.2	7.2	8.5	8.8
PI 482319	7.6	8.7	6.7	7.5	7.0	7.2	8.5	8.5
PI 164687	7.6	8.9	5.9	6.9	7.6	7.7	8.7	8.9
PI 482317	7.7	9.0	5.6	6.5	8.0	8.2	9.0	9.0
PI 482254	7.8	8.9	5.7	7.1	8.0	8.2	8.8	8.8
PI 234287	7.9	9.0	6.1	7.1	7.8	8.4	9.0	9.0
PI 163203	8.0	9.0	6.4	7.1	8.0	8.3	9.0	9.0
PI 254624	8.0	9.0	6.1	7.3	8.2	8.2	9.0	9.0
PI 482299	8.0	9.0	7.0	7.2	7.7	8.0	9.0	9.0
PI 175663	8.1	9.0	7.1	7.7	7.6	7.9	9.0	9.0
PI 490376	8.2	9.0	6.7	7.7	8.2	8.6	9.0	9.0
PI 482309	8.3	9.0	6.7	7.9	8.4	8.5	9.0	9.0
PI 505604	8.3	9.0	7.5	8.1	7.9	8.3	9.0	9.0
PI 174105	8.4	9.0	6.9	7.8	8.8	8.9	9.0	9.0
PI 275628	8.4	9.0	6.7	7.9	9.0	9.0	9.0	9.0
PI 378617	8.5	9.0	7.4	7.9	8.4	9.0	9.0	9.0

(continued next page)

Table 1.3. (continued)

Accession name	Average rating	Maximum rating	Rating date 1	2	3	4	5	6
Charleston Gray	8.6	9.0	7.4	8.3	9.0	9.0	9.0	9.0
PI 169243	8.7	9.0	7.5	8.5	9.0	9.0	9.0	9.0
PI 177329	8.9	9.0	8.3	9.0	9.0	9.0	9.0	9.0

[+] Analysis performed for means of each rating date plus the overall averages. Rating dates were at one-week intervals beginning two weeks after inoculation (first true-leaf stage). Plants were rated on a scale of 0 to 9 on the basis of severity of viral symptoms, where 0=none, 1-2=trace, 3-4=slight, 5-6=moderate, 7-8=severe, and 9=plant dead. Average rating is the mean of the ratings of all 21 plants. Maximum ratings is the mean of the final rating of all 21 plants per PI accession. Rank indicates the ranking of the cultigen for resistance to PRSV-W, based on average and maximum rating.

Table 1.4. Mean resistance ratings of the most resistant 60 and most susceptible 12 cultigens (along with 2 checks) of watermelon for PRSV-W in the final retest.[+]

Rank	Accession or cultivar	Country of origin	Virus rating			Maximum rating			
			Best	Ave.	Max.	Rep1	Rep2	Rep3	Rep4
Resistant									
1	PI 244019	S. Africa	2.5	2.4	3.1	3.6	3.6	2.5	2.6
2	PI 244017	S. Africa	2.6	2.4	2.9	3.0	3.4	2.6	2.8
3	PI 482342	Zimbabwe	2.7	2.7	3.1	2.5	4.7	2.7	2.9
4	PI 482318	Zimbabwe	3.0	3.6	4.3	5.9	5.3	3.0	2.9
5	PI 485583	Botswana	3.1	2.7	3.5	3.1	4.5	3.1	3.2
6	PI 482379	Zimbabwe	3.4	3.5	4.1	4.1	5.6	3.4	3.3
7	PI 595203	USA	3.5	2.9	3.4	3.5	3.3	3.5	3.4
8	PI 512364	Spain	3.5	8.1	8.6	9.0	8.9	8.0	8.6
9	PI 244018	S. Africa	3.6	3.0	3.5	3.6	3.1	3.6	3.6
10	PI 234287	Portugal	4.0	8.1	8.6	9.0	8.4	8.5	8.4
11	PI 482315	Zimbabwe	4.3	4.7	5.4	7.0	6.3	4.3	4.1
12	PI 482322	Zimbabwe	4.9	4.4	5.2	5.5	7.0	4.9	3.3
13	PI 255137	S. Africa	5.8	5.3	6.0	5.0	7.8	5.8	5.5
14	PI 482299	Zimbabwe	5.9	5.2	6.1	5.0	7.8	5.9	5.9
Susceptible									
15	PI 169238	Turkey	6.3	8.1	8.6	9.0	8.3	8.6	8.6
16	PI 482312	Zimbabwe	6.8	6.1	6.8	5.5	8.1	6.8	6.9

(continued next page)

Table 1.4. (continued)

Rank	Accession or cultivar	Country of origin	Virus rating Best	Ave.	Max.	Maximum rating Rep1	Rep2	Rep3	Rep4
17	PI 482261	Zimbabwe	7.0	4.8	5.6	4.1	4.3	7.0	6.9
19	PI 307609	Nigeria	7.0	7.0	7.6	8.8	7.6	7.0	7.3
20	PI 314655	Soviet Union	7.0	7.4	8.0	-	-	7.0	8.3
21	PI 526235	Zimbabwe	7.3	7.5	8.1	8.9	8.6	7.3	7.5
22	PI 357735	Yugoslavia	7.3	8.1	8.6	9.0	8.8	8.3	8.5
23	PI 164665	India	7.3	8.1	8.6	9.0	8.9	8.1	8.5
24	PI 345543	Soviet Union	7.4	7.2	8.0	8.8	8.9	7.4	7.0
25	PI 482305	Zimbabwe	7.5	7.1	7.7	8.5	7.0	7.5	7.9
26	PI 271132	Tunisia	7.5	7.3	7.9	7.9	9.0	7.5	7.4
27	PI 275628	Pakistan	7.5	7.9	8.3	9.0	8.8	7.5	8.1
28	PI 169232	Turkey	7.6	7.6	8.2	9.0	8.8	7.6	7.5
29	PI 278009	Turkey	7.6	7.6	8.2	9.0	8.1	7.6	8.0
30	PI 346082	Afghanistan	7.8	7.1	7.6	7.8	7.0	7.8	9.0
31	PI 195562	Ethiopia	7.8	7.6	8.1	9.0	8.0	7.8	7.8
32	PI 500332	Zambia	7.9	7.6	8.2	7.8	9.0	7.9	8.3
33	PI 174104	Turkey	7.9	7.7	8.3	9.0	8.1	7.9	8.3
34	PI 177328	Turkey	7.9	7.9	8.5	9.0	8.8	7.9	8.4
35	PI 254741	Senegal	7.9	8.0	8.5	9.0	8.8	7.9	8.3
36	PI 169241	Turkey	8.0	7.7	8.3	9.0	8.0	8.0	8.3

(continued next page)

Table 1.4. (continued)

Rank	Accession or cultivar	Country of origin	Virus rating Best	Ave.	Max.	Maximum rating Rep1	Rep2	Rep3	Rep4
37	PI 534592	Syria	8.0	7.7	8.3	8.3	8.5	8.0	8.6
38	PI 482269	Zimbabwe	8.0	7.7	8.3	9.0	8.5	8.0	7.9
39	PI 525086	Egypt	8.0	7.8	8.3	9.0	8.4	8.0	8.0
40	PI 254742	Senegal	8.0	7.9	8.5	9.0	8.9	8.0	8.1
41	PI 278027	Turkey	8.0	8.2	8.6	9.0	9.0	8.0	8.2
42	PI 512406	Spain	8.1	7.7	8.3	8.3	8.6	8.1	8.3
43	PI 534584	Syria	8.1	7.8	8.5	8.5	9.0	8.1	8.5
44	PI 357690	Yugoslavia	8.1	7.9	8.4	9.0	7.9	8.1	8.6
45	PI 176489	Turkey	8.1	7.9	8.5	9.0	8.6	8.1	8.3
46	PI 172803	Turkey	8.1	7.9	8.6	9.0	8.6	8.1	8.3
47	PI 532817	China	8.1	7.9	8.4	9.0	8.0	8.1	8.5
48	PI 176499	Turkey	8.1	8.0	8.6	9.0	9.0	8.1	8.3
49	PI 319212	Egypt	8.3	7.8	8.6	9.0	8.8	8.3	8.3
50	PI 178873	Turkey	8.3	7.8	8.4	9.0	8.3	8.3	8.1
51	PI 502319	Uzbekistan	8.3	7.9	8.6	9.0	8.8	8.3	8.3
52	PI 279461	Japan	8.3	7.9	8.6	9.0	8.6	8.3	8.5
53	PI 379245	Yugoslavia	8.4	7.1	7.8	7.9	6.5	8.4	8.6
54	PI 278008	Turkey	8.4	7.5	8.1	8.0	7.3	8.4	8.6
55	PI 537271	Pakistan	8.4	7.7	8.3	8.3	8.1	8.4	8.5

(continued next page)

Table 1.4. (continued)

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Ave.	Virus rating Max.	Maximum rating Rep1	Maximum rating Rep2	Maximum rating Rep3	Maximum rating Rep4
56	PI 357679	Yugoslavia	8.4	7.8	8.3	9.0	7.5	8.4	8.4
57	PI 176490	Turkey	8.4	7.9	8.6	8.9	8.9	8.4	8.1
58	PI 246559	Senegal	8.4	8.0	8.6	9.0	8.6	8.4	8.4
59	PI 508442	S.Korea	8.5	7.7	8.4	9.0	7.8	8.5	8.5
60	PI 277972	Turkey	8.5	7.9	8.5	8.4	8.6	8.5	8.5
61	PI 277989	Turkey	8.5	8.2	8.7	9.0	9.0	8.5	8.5
62	PI 164737	India	8.5	8.4	8.8	9.0	8.6	8.5	9.0
63	PI 525088	Egypt	8.6	7.8	8.5	8.9	8.3	8.6	8.4
64	PI 500309	Zambia	8.6	8.1	8.7	8.8	8.8	8.6	8.6
65	PI 357752	Yugoslavia	8.6	8.2	8.8	9.0	9.0	8.6	8.5
66	PI 278026	Turkey	8.6	8.3	8.7	9.0	8.5	8.6	8.6
67	PI 271986	Somalia	8.7	7.6	8.3	7.1	8.3	8.7	9.0
68	PI 532667	Switzerland	-	7.7	8.4	8.3	8.5	-	-
69	PI 536450	Maldives	-	8.0	8.7	9.0	-	-	8.4
70	PI 278058	Turkey	8.8	8.6	8.8	8.9	8.5	8.8	9.0
71	PI 278005	Turkey	8.9	8.1	8.7	8.8	8.5	8.9	8.5
72	PI 277990	Turkey	9.0	8.8	9.0	-	9.0	9.0	-
73	Charleston Gray	Check	9.0	8.7	8.9	9.0	8.8	9.0	9.0
74	Crimson Sweet	Check	9.0	8.8	9.0	9.0	8.9	9.0	9.0
LSD (5%)			1.4	1.5	1.4	-	-	-	-

[+] Analysis performed for means of each rating date plus the overall averages. Plants were rated on a scale of 0 to 9 on the basis of severity of viral symptoms, where 0= none, 1-2= trace, 3-4= slight, 5-6= moderate, 7-8= severe, and 9= plant dead. Average rating is the mean of the ratings of all 74 plants. Maximum ratings are the mean of the final rating of all 74 plants per PI accession. Rank indicates the ranking of the cultigen for resistance to PRSV-W, based on best rating (as well as average and maximum ratings; data not shown).

Chapter Two

Screening the Watermelon Cultivars and Plant Introduction Accessions For Resistance to *Papaya Ringspot Virus Type-W* in Watermelon

((In the format appropriate for submission to the Journal of the American Society for Horticultural Science)

For: Journal of ASHS

Breeding and Genetics

Screening Watermelon Cultivars and Plant Introduction Accessions For Resistance to *Papaya Ringspot Virus Type-W* in Watermelon

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Additional index words. Cucurbitaceae, Citrullus lanatus, *Papaya ringspot virus watermelon strain*, disease resistance, mosaic, pathology, vegetable breeding

Received for publication _____. The research reported herein was funded in part by the North Carolina Agricultural Research Service. Use of trade names in this publication does not imply endorsement by the NCARS or the products named, or criticism of similar ones not mentioned.

Graduate research assistants, assistant professor, and professor, respectively. The authors gratefully acknowledge the technical assistance of Tammy L. Ellington.

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Screening Watermelon Cultivars and Plant Introduction Accessions For Resistance to *Papaya Ringspot Virus Type-W* in Watermelon

Additional index words. Cucurbitaceae, Citrullus lanatus, *Papaya ringspot virus watermelon strain*, disease resistance, mosaic, pathology, vegetable breeding

Abstract

Papaya ringspot virus-watermelon strain (PRSV-W) affects all agriculturally important species of the Cucurbitaceae, and is of economic interest because of its destructiveness. Plant breeders need sources of resistance that can be incorporated into adapted breeding lines to help control the disease. The United States Department of Agriculture, Agricultural Research Service (USDA-ARS) watermelon germplasm collection was screened for resistance to PRSV-W by the Cucurbit Breeding Project at North Carolina State University. The objectives of this study were to screen additional PI accessions and watermelon cultivars for resistance to PRSV-W. The experiment was a randomized complete block with four replications of 153 PI accessions and 44 watermelon cultivars. The susceptible checks were the elite cultivars 'Calhoun Gray' and 'Crimson Sweet' (known to be susceptible to PRSV-W). The cultigens were inoculated with a virulent isolate of PRSV-W (isolate 2052). Plants were inoculated by using the rub method at the first true leaf stage, and rated on a 0 to 9 scale three times weekly starting two weeks after inoculation. There were significant differences (0.01 level) among cultigens for all rating dates. PI 278043, PI 532669 and PI 306782 were selected as the most resistant PI accessions to be used in future breeding efforts. The most susceptible PI accessions were: PI 274035, PI 357697, PI 357737, and PI 278038. None of watermelon cultivars showed high resistance to PRSV-W. However, relative to the other cultivars screened, 'Verona', 'Graybelle', and 'Florida Favorite' were the more resistant inbred cultivars

within the old cultivars. 'Allsweet', 'Sugar Baby', 'Peacock WR 60', 'Dixielee', and 'Charleston Gray' were the most susceptible inbred cultivars with a best rating of 9.0.

Watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai) is a major crop in the southern United States. Around the world, over 10 viruses are known to be a problem in watermelon production (Provvidenti, 1986b). The major viruses affecting watermelon in the United States are *Papaya ringspot virus-watermelon strain* (PRSV-W, formerly *Watermelon mosaic virus-1*), *Watermelon mosaic virus* (WMV, formerly *Watermelon mosaic virus-2*), and *Zucchini yellow mosaic virus* (ZYMV) (Adlerz and Crall, 1967; Mohr, 1986; Provvidenti, 1991; Wehner et al., 2001). Virus diseases are destructive to the watermelon crop, and are difficult to control (Sherf and Macnab, 1986). The major control strategies involve insecticides to eliminate the insect vectors, herbicides to remove alternate hosts, or genetic resistance (Provvidenti, 1993).

Although resistance is generally pathogen-specific (Grumet, 1989), the most economical method for control of virus diseases is genetic resistance. Virus resistance in some cucurbits has been provided by virus coat proteins (Namba et al., 1992; Quemada et al., 1990). That technology may provide additional resistance if it can be used successfully in watermelon. However, natural resistance is often available to cucurbit breeders (Provvidenti, 1993). Already, the watermelon germplasm collection has been screened for resistance to some virus diseases. Boyhan et al. (1992) and Provvidenti (1986a and 1991) have identified PI accessions resistant to ZYMV, and Gillaspie and Wright (1993) have identified PI accessions resistant to WMV.

PRSV-W virus affects all agricultural species of the Cucurbitaceae, and is of great economic importance because of its destructiveness (Provvidenti, 1993). PRSV-W has been described as one of the five most important viruses in field-grown vegetables (Tomlinson, 1987). Type W isolates have been reported in cucurbits in many areas including the USA, Mexico, the Caribbean islands, Australia, Germany, France, Italy, India, countries of the Middle East, and South America (Murant and Harrison, 1984; Purcifull et al., 1984). PRSV-W was known as watermelon mosaic virus-1 until it was shown that it was in fact a strain of *Papaya ringspot virus* (Provvidenti, 1993). The virus is transmitted in a non-

persistent manner by 24 species in 15 genera of aphid. Resistance to the virus has been identified in cucumber (*Cucumis sativus*), melon (*Cucumis melo*), squash (*Cucurbita* spp.), and gourds (*Lagenaria* spp. and *Luffa* spp.) (Provvidenti, 1993).

Watermelon has not been screened extensively for resistance to PRSV-W until recently. Munger et al. (1984) tested seven watermelon PI accessions for resistance to PRSV-W using an unidentified isolate of PRSV-W. Hojo et al. (1991a) used an aggressive isolate, Ab-081, to screen some Brazilian watermelon accessions for virus resistance. Only one Brazilian resistant accession, BT-8501, a wild, bitter-fruited watermelon from Africa was identified (Hojo et al., 1991b). More recently, watermelon was extensively screened for resistance to PRSV-W by our group (Strange et al. 2002). In this study, a total of 1275 watermelon plant introduction (PI) accessions, obtained from the Southern Regional Plant Introduction Station at Griffin, Georgia, were screened by using a severe isolate of PRSV-W, 2052 described by Baker et al. (1991), obtained from D.E. Purcifull, University of Florida, Gainesville. Not all of the 1275 accessions germinated in all replications during germplasm screening. Data was collected on 1248 of those accessions.

Most watermelon cultivars and inbred lines have not been screened for resistance to PRSV-W. We were interested in screening the watermelon cultivars because if any of them were found to be resistant to PRSV-W, it would be very easy to transfer this resistance to other watermelon cultivars since they are already true to type. The objective of this study was to screen as many watermelon cultivars as we could obtain along with the PI accessions in the USDA germplasm not screened in our previous study for resistance to PRSV-W.

Materials and Methods

The screening experiment was conducted in the greenhouses of the department of Plant Pathology, North Carolina State University, Raleigh, NC. Greenhouse temperatures averaged 23 to 43°C day and 12 to 24°C night.

Germplasm Evaluated

Cultigens that were not properly tested in our original germplasm screening study (Strange et al., 2002) were considered for testing in this study. A total of 153 PI accessions were determined to be

available from the USDA germplasm collection, but not properly tested originally. In addition, 44 watermelon cultivars were chosen based on the availability of the seeds. Two susceptible check cultivars were also included: 'Calhoun Gray' and 'Crimson Sweet'.

Inoculation

The virus isolate was obtained from D.E. Purcifull, University of Florida, Gainesville. The PRSV-W isolate used was 2052 described by Baker et al. (1991) and the host plant used for virus multiplication and as a source of inoculum was 'Gray Zucchini' squash (*Cucurbita pepo* L.) from Seminis Vegetable Seeds (Woodland, CA).

Inoculum was prepared by grinding infected 'Gray Zucchini' squash leaves using mortar and pestle in 0.02 M phosphate buffer, pH 7.0. Leaf to buffer ratio was 1:5 (1 g infected leaf to 5 ml buffer). All 'Gray Zucchini' squash plants for virus production were seeded in metromix 200 (Scotts-Sierra Horticultural Products Company, Marysville, Ohio) in 160 mm diameter (6 inch, 1550 ml volume) clay pots. Plants were fertilized weekly with 150 $mg \cdot kg^{-1}$ 20-20-20 N-P-K Peters Professional (Scotts-Sierra Horticultural Products Company, Marysville, Ohio). The squash plants were kept in aphid-proof cages to prevent contamination by other viruses.

The inoculation procedure used for increasing the PRSV-W isolate in squash and for the screening experiment was the rub method (Guner et al. 2002). That method consisted of dusting the first true leaf on each plant with carborundum (800 mesh, Fisher Scientific Co., Fair Lawn, NJ), then applying the inoculum to the leaf with a pestle rotated in a circular motion. After inoculation, carborundum was rinsed off the leaves with water to prevent shading.

Germplasm screening

The experiment was a randomized complete block with four replications of 44 watermelon cultivars and 153 PI accessions, along with two susceptible checks ('Calhoun Gray' and 'Crimson Sweet'). The cultivars were obtained from seed companies and university plant breeders around the U.S. PI accessions that did not germinate in at least three replications out of four in a previous germplasm screening (Strange et al., 2002) were included in this study. All *Citrullus* PI accessions were obtained from the Southern Regional Plant Introduction Station at Griffin, Georgia.

Plots consisted of two 100 x 100 mm square pots (600 ml volume). Extra pots of each accession were planted to assure that all plots would have the same number of plants even with differences in germination. The cultigens were inoculated with isolate 2052, the most virulent isolate of PRSV-W in our collection. Plants were inoculated using the rub method at the first true leaf stage, and rated three times at one week intervals starting two weeks after inoculation.

Variability

PI accessions can be variable, especially when they are collected as samples from wild populations. It is possible that resistant plants exist within an accession that is mostly susceptible. Therefore, we measured variability within cultigens to determine whether PI accessions were more variable than inbred cultivars.

Traits evaluated

Plants were rated visually on a scale of 0 to 9 on the basis of severity of viral symptoms, where 0=none, 1-2=trace, 3-4=slight, 5-6=moderate, 7-8=severe, and 9=plant dead. For each plot, the maximum, minimum, and average rating among the eight plants was recorded. Average rating was the overall average of all the ratings averaged over replications. Maximum rating was the maximum of all the ratings averaged over replications.

Data analysis

Data were analyzed using the MEANS, ANOVA and GLM procedures of the SAS statistical package (SAS Institute, Cary, NC).

Results and Discussion

A total of 199 cultigens including two checks 'Calhoun Gray' and 'Crimson Sweet' were screened for resistance to PRSV-W. Not all of the PI accessions and watermelon cultivars germinated in all four replications (Table 2.1). A total of 40 PI accessions did not germinate in all four replications. These PIs were Grif 1728, PI 175657, PI 176915, PI 176923, PI 181744, PI 183023, PI 185635, PI 240532, PI 254429, PI 266027, PI 270524, PI 271468, PI 271767, PI 271770, PI 271771, PI 277983, PI 277986, PI 278010, PI 278021, PI 278030, PI 278036, PI 278049, PI 278060, PI 279456, PI 290855, PI 314148, PI 325248, PI 344066, PI 345545, PI 346787, PI 357710, PI 357730, PI 357745, PI 385964, PI 508443, PI

512393, PI 525081, PI 532664, PI 534590 and PI 549160. Four PI accessions did not germinate in three replications while 14 germinated only in two replications. A total of 135 germinated at least in three replications of four replications. Cultivars 'Mickylee', 'Petite Sweet', and 'Early Canada' germinated only in two replications, while rest of the watermelon cultivars germinated at least in three replications.

The ANOVA indicated that there were significant differences (0.01 level) among cultigens for all rating dates (Appendix table 2). Most of the 199 PIs and the watermelon cultivars were susceptible and had best ratings of 5.8 or higher (Table 2.1). There were only three PI accessions with a best rating 6.0 or less: PI 278043 (5.8), PI 532669 (6.0), and PI 306782 (6.0). There were four cultigens with a best rating of 6 to 7, 15 cultigens with a best rating of 7 to 8, and 177 cultigens with a best rating of 8 to 9. The check cultivars, 'Calhoun Gray' and 'Crimson Sweet', both had a best rating of 9.0. A total of 22 cultigens (including 'Allsweet', 'Sugar Baby', 'Peacock WR 60', 'Dixielee', and 'Charleston Gray') had best ratings of 9.0, showing high susceptibility to PRSV-W (Table 2.1). Accessions with a best rating of 9.0 were PI 277992, PI 176905, PI 357680, PI 418762, PI 368524, PI 172798, PI 240533, PI 182183, PI 207471, PI 296335, PI 288316, PI 278038, PI 357737, PI 274035, and PI 357697. These susceptible PI accessions can be used as susceptible checks for breeding and inheritance studies of PRSV-W. None of the cultivars had resistance to PRSV-W. 'Verona' was the more resistant cultivar among the watermelon cultivars, with a best rating of 7.0. Only three watermelon cultivars had a best rating of 8.0 and less: 'Graybelle' (best rating of 7.6), 'Florida Favorite' (best rating of 7.8), and 'Early Canada' (best rating of 8.0). The other watermelon cultivars had best ratings of 8.0 or higher, indicating that they were highly susceptible to PRSV-W.

Plant-to-plant variation within cultigen was similar for PI accessions and inbred cultivars (Table 2.2). Cultigens with a best rating of 6.0 or less might be of some for their intermediate resistance. Our results showed that most of the watermelon cultivars were highly susceptible to PRSV-W, indicating that there is a need for sources of resistance to PRSV-W in order to breed resistant watermelon cultivars. Currently, there are not any commercially available watermelon cultivars with resistance to PRSV-W. Our results also showed that the check cultivars used in this study were highly susceptible to PRSV-W. PI 274035 (average rating of 8.8) and PI 357697 (average rating of 8.9) had same best rating as the checks,

but had a higher average rating than the checks. 'Calhoun Gray', 'Crimson Sweet', PI 274035, and PI 357697 would be useful as susceptible checks for breeding and inheritance studies for resistance to PRSV-W.

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Table 2.1. Resistance ratings of 199 watermelon cultigens, including the checks inoculated with PRSV-W.[z]

Rank	Accession or cultivar	Country of origin	Virus rating			Maximum rating			
			Best	Average	Max.	Rep 1	Rep 2	Rep 3	Rep 4
01	PI 278043	Turkey	5.8	4.9	5.8	4.7	.	5.2	-
02	PI 532669	Botswana	6.0	4.7	6.0	4.8	4.5	4.7	4.7
03	PI 306782	Nigeria	6.0	5.1	6.0	5.2	5.0	5.2	5.2
04	PI 345547	Soviet Union	6.3	5.0	6.3	5.3	4.8	4.8	5.0
05	PI 182178	Turkey	6.3	5.4	6.3	5.7	5.0	5.2	5.7
06	PI 307608	Nigeria	6.4	5.1	6.4	5.3	4.8	5.3	4.8
07	PI 169289	Turkey	6.9	6.0	6.9	6.0	5.5	6.2	6.2
08	Verona	USA	7.1	6.5	7.1	6.7	6.3	6.5	6.7
09	PI 490385	Mali	7.3	6.5	7.3	6.8	-	-	6.2
10	PI 176907	Turkey	7.4	6.6	7.4	7.0	6.7	6.7	6.0
11	PI 532670	Botswana	7.5	6.5	7.5	7.0	-	6.0	-
12	PI 299378	S. Africa	7.6	6.7	7.6	6.8	7.0	6.7	6.3
13	Graybelle	USA	7.6	6.8	7.6	6.7	7.0	7.0	6.7
14	PI 273480	Ethiopia	7.7	6.9	7.7	-	8.7	6.5	5.5
15	Florida Favorite	USA	7.8	7.0	7.8	6.8	7.0	6.8	7.2
16	PI 331106	Uruguay	7.8	7.1	7.8	-	6.3	7.0	8.0
17	PI 228238	Israel	7.9	6.9	7.9	7.0	7.2	5.8	7.7
18	PI 247399	Greece	8.0	6.8	8.0	7.0	7.2	6.0	7.2
19	PI 274034	S. Africa	8.0	7.0	8.0	-	7.0	-	-
20	PI 542123	Botswana	8.0	7.0	8.0	-	7.0	7.0	-
21	Early Canada	USA	8.0	7.3	8.0	-	7.3	7.2	-

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Table 2.1. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating			Maximum rating			
			Best	Average	Max.	Rep 1	Rep 2	Rep 3	Rep 4
22	PI 183217	Egypt	8.0	7.3	8.0	7.0	6.8	7.8	7.7
23	PI 277971	Turkey	8.1	7.2	8.1	8.0	6.0	8.5	6.2
24	Congo	USA	8.1	7.3	8.1	6.7	8.0	8.0	6.3
25	PI 225557	Zimbabwe	8.2	7.1	8.2	6.7	6.7	8.0	-
26	PI 482354	Zimbabwe	8.2	7.2	8.2	-	8.0	6.3	7.3
27	PI 357706	Yugoslavia	8.2	7.2	8.2	8.0	7.0	6.7	-
28	PI 277979	Turkey	8.2	7.4	8.2	-	7.8	6.7	7.8
29	PI 254744	Senegal	8.2	7.4	8.2	-	7.0	7.0	8.3
30	PI 169299	Turkey	8.3	7.3	8.3	7.0	7.8	6.5	7.7
31	Navajo Sweet	USA	8.3	7.3	8.3	7.2	8.3	8.0	5.8
32	PI 357678	Yugoslavia	8.3	7.3	8.3	8.3	6.0	8.0	7.0
33	PI 278002	Turkey	8.3	7.3	8.3	7.7	8.0	6.7	7.0
34	PI 278050	Turkey	8.3	7.4	8.3	7.0	7.8	8.5	6.3
35	PI 177321	Turkey	8.3	7.6	8.3	8.7	8.2	6.8	6.7
36	PI 277981	Turkey	8.3	7.7	8.3	7.3	8.0	-	-
37	PI 278004	Turkey	8.3	7.7	8.3	7.3	8.0	-	-
38	PI 500304	Zambia	8.3	7.2	8.3	6.7	7.3	7.5	-
39	Kleckley Sweet	USA	8.3	7.3	8.3	-	8.2	7.2	6.5
40	PI 296341	S. Africa	8.3	7.4	8.3	-	6.3	7.7	8.2
41	PI 278022	Turkey	8.3	7.4	8.3	-	8.7	6.3	7.3

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Table 2.1. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating			Maximum rating			
			Best	Average	Max.	Rep 1	Rep 2	Rep 3	Rep 4
42	PI 482336	Zimbabwe	8.3	7.5	8.3	-	8.0	6.7	7.8
43	PI 270565	S. Africa	8.3	7.9	8.3	6.3	8.7	8.7	-
44	Golden Honey	USA	8.4	7.3	8.4	6.2	8.0	7.0	7.8
45	PI 512345	Spain	8.4	7.3	8.4	7.2	8.0	7.0	7.0
46	Regency	USA	8.4	7.4	8.4	7.3	8.0	7.0	7.2
47	PI 357734	Yugoslavia	8.4	7.7	8.4	7.0	8.5	7.8	7.3
48	PI 344395	Iran	8.5	7.3	8.5	7.5	7.3	7.0	7.2
49	PI 260733	Sudan	8.5	7.4	8.5	7.7	7.8	7.0	7.2
50	PI 222184	Afghanistan	8.5	7.5	8.5	7.5	-	8.0	7.0
51	PI 270525	Israel	8.5	7.5	8.5	-	8.0	7.8	6.7
52	PI 270563	S. Africa	8.5	7.6	8.5	-	6.5	7.7	8.5
53	Petit Sweet	USA	8.5	7.6	8.5	-	8.2	7.0	-
54	PI 278011	Turkey	8.5	7.6	8.5	7.0	8.0	7.8	7.7
55	PI 357681	Yugoslavia	8.5	7.6	8.5	6.5	8.0	8.5	7.5
56	PI 370428	Yugoslavia	8.5	7.7	8.5	7.8	7.3	8.0	7.7
57	PI 504519	Australia	8.5	7.7	8.5	8.0	8.0	8.8	6.0
58	Stars N Stripes	USA	8.5	7.7	8.5	8.3	8.2	6.7	-
59	PI 278047	Turkey	8.5	7.8	8.5	8.7	8.0	7.7	6.7
60	Yellow Crimson	USA	8.5	7.8	8.5	6.2	8.7	8.7	7.5
61	PI 278013	Turkey	8.5	7.8	8.5	8.0	8.7	8.2	6.3
62	Calsweet	USA	8.5	7.8	8.5	8.0	8.7	7.2	7.3

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Table 2.1. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Maximum rating Rep 1	Maximum rating Rep 2	Maximum rating Rep 3	Maximum rating Rep 4
63	PI 319235	Japan	8.5	7.8	8.5	8.2	8.2	7.2	7.7
64	PI 277993	Turkey	8.5	7.8	8.5	6.0	8.7	8.7	8.0
65	PI 278006	Turkey	8.5	7.9	8.5	8.3	8.7	8.0	6.7
66	PI 177324	Turkey	8.5	8.0	8.5	6.8	8.7	8.7	8.0
67	Tastigold	USA	8.6	7.3	8.6	7.0	7.7	7.3	7.3
68	PI 357667	Yugoslavia	8.6	7.5	8.6	7.2	8.0	7.3	7.7
69	PI 277998	Turkey	8.6	7.5	8.6	6.2	8.0	8.0	8.0
70	PI 177323	Turkey	8.6	7.6	8.6	6.7	7.8	8.2	7.7
71	Starbrite	USA	8.6	7.6	8.6	7.8	8.2	7.7	6.8
72	Burrel Gray	USA	8.6	7.7	8.6	8.3	7.8	7.2	7.3
73	PI 357663	Yugoslavia	8.6	7.7	8.6	6.8	8.3	7.7	7.8
74	PI 357738	Yugoslavia	8.6	7.7	8.6	8.8	8.0	7.2	6.7
75	Yellow Shipper	USA	8.6	7.8	8.6	8.5	8.3	6.3	8.0
76	PI 277987	Turkey	8.6	7.8	8.6	8.0	8.0	8.3	6.8
77	Black Diamond YF	USA	8.6	7.9	8.6	8.0	8.0	8.7	6.8
78	Yellow Rose	USA	8.6	7.9	8.6	8.7	8.3	7.3	7.2
79	Tendergold	USA	8.6	7.9	8.6	7.8	8.7	7.7	7.5
80	PI 222710	Iran	8.6	8.0	8.6	7.8	8.0	8.2	7.8
81	PI 278015	Turkey	8.6	8.1	8.6	8.7	7.8	9.0	6.8
82	PI 276659	Former Soviet Union	8.7	7.5	8.7	-	8.2	7.5	6.8
83	PI 169263	Turkey	8.7	7.7	8.7	-	7.7	7.5	7.8

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Table 2.1. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Maximum rating Rep 1	Maximum rating Rep 2	Maximum rating Rep 3	Maximum rating Rep 4
84	PI 222775	Iran	8.7	7.7	8.7	7.8	-	8.7	6.7
85	King and Queen	USA	8.7	7.7	8.7	-	8.5	7.7	7.0
86	PI 254737	Senegal	8.7	7.8	8.7	8.0	8.3	-	7.0
87	PI 182934	India	8.7	7.8	8.7	-	8.3	7.3	7.8
88	Peacock Striped	USA	8.7	7.8	8.7	7.5	8.2	7.8	-
89	PI 241689	Chile	8.7	7.9	8.7	8.0	7.8	7.8	-
90	Jubilee	USA	8.7	7.9	8.7	7.8	8.3	-	7.5
91	Peacock Shipper	USA	8.7	7.9	8.7	8.3	8.3	7.0	-
92	PI 229605	Iran	8.7	7.9	8.7	8.2	8.2	7.5	-
93	Black Diamond	USA	8.7	8.1	8.7	8.8	-	8.2	7.2
94	Tendersweet OF	USA	8.7	8.1	8.7	-	8.0	8.7	7.5
95	New H. Midget	USA	8.7	8.1	8.7	8.0	-	8.3	8.0
96	Yellow Baby	USA	8.8	7.4	8.8	7.2	8.2	6.7	7.7
97	Blackstone	USA	8.8	7.7	8.8	7.5	8.2	7.5	7.5
98	PI 177319	Turkey	8.8	7.8	8.8	7.7	7.8	-	-
99	PI 314178	Former Soviet Union	8.8	7.8	8.8	7.8	7.7	8.0	7.5
100	PI 319237	Japan	8.8	7.8	8.8	8.2	8.7	6.7	7.7
101	PI 278053	Turkey	8.8	7.8	8.8	7.8	8.0	8.0	7.5
102	PI 295845	S. Africa	8.8	7.8	8.8	7.5	8.0	7.8	8.0
103	Super Sweet	USA	8.8	7.8	8.8	8.7	8.3	7.2	7.2
104	PI 181938	Syria	8.8	7.9	8.8	8.2	7.7	8.0	7.7

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Table 2.1. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating			Maximum rating			
			Best	Average	Max.	Rep 1	Rep 2	Rep 3	Rep 4
105	Mickylee	USA	8.8	7.9	8.8	8.2	7.7	-	-
106	PI 344300	Turkey	8.8	7.9	8.8	8.0	8.2	7.7	7.8
107	PI 368520	Yugoslavia	8.8	7.9	8.8	7.3	8.2	8.3	7.8
108	PI 211917	Iran	8.8	8.0	8.8	8.7	7.8	7.8	7.5
109	PI 173668	Turkey	8.8	8.0	8.8	7.2	8.7	8.2	7.8
110	PI 212209	Greece	8.8	8.0	8.8	9.0	8.2	7.5	7.5
111	PI 222715	Iran	8.8	8.1	8.8	7.7	-	8.5	-
112	Sweet Princess	USA	8.8	8.1	8.8	8.8	7.8	8.8	6.8
113	PI 270308	Philippines	8.8	8.2	8.8	7.8	8.3	8.7	7.8
114	PI 270562	S. Africa	8.8	7.7	8.8	-	7.7	7.5	8.0
115	PI 357739	Yugoslavia	8.8	7.7	8.8	7.2	8.0	-	8.0
116	PI 277988	Turkey	8.8	7.9	8.8	8.0	-	8.2	7.5
117	PI 169277	Turkey	8.8	7.9	8.8	-	8.0	8.7	7.0
118	Garrisonian	USA	8.8	8.0	8.8	8.2	8.7	-	7.2
119	Klondike #11	USA	8.8	8.1	8.8	7.5	8.3	8.3	-
120	PI 176498	Turkey	8.8	8.1	8.8	8.2	8.7	7.3	-
121	PI 277978	Turkey	8.8	8.1	8.8	-	7.8	8.0	8.3
122	PI 277999	Turkey	8.8	8.1	8.8	8.2	8.2	7.8	-
123	PI 278061	Turkey	8.8	8.1	8.8	-	8.0	8.2	8.0
124	PI 251796	Yugoslavia	8.8	8.2	8.8	7.7	8.7	8.3	-
125	PI 169290	Turkey	8.8	8.3	8.8	7.7	8.7	8.5	-

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Table 2.1. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating			Maximum rating			
			Best	Average	Max.	Rep 1	Rep 2	Rep 3	Rep 4
126	PI 357682	Yugoslavia	8.8	8.4	8.8	8.7	-	8.7	7.8
127	PI 306367	Angola	8.9	7.7	8.9	7.3	8.0	8.0	7.3
128	PI 357718	Yugoslavia	8.9	7.8	8.9	6.7	8.7	8.5	7.3
129	PI 278020	Turkey	8.9	7.8	8.9	7.3	8.7	8.0	7.3
130	Minilee	USA	8.9	7.8	8.9	7.8	8.0	8.3	7.2
131	Super Gold	USA	8.9	7.9	8.9	7.8	8.7	7.2	8.0
132	Smokylee	USA	8.9	8.0	8.9	7.7	8.0	8.0	8.2
133	PI 278003	Turkey	8.9	8.0	8.9	8.0	8.0	8.3	7.5
134	PI 293766	Former Soviet Union	8.9	8.0	8.9	7.0	8.2	8.0	8.8
135	Red'N'Sweet	USA	8.9	8.0	8.9	7.8	8.7	8.5	7.2
136	PI 278055	Turkey	8.9	8.0	8.9	8.3	8.0	8.5	7.3
137	Summer Gold	USA	8.9	8.2	8.9	8.3	8.3	8.3	7.7
138	PI 277992	Turkey	9.0	7.8	9.0	-	8.0	7.8	7.7
139	PI 176905	Turkey	9.0	7.9	9.0	8.2	8.0	7.5	-
140	PI 357680	Yugoslavia	9.0	8.1	9.0	-	8.2	-	8.0
141	Charleston Gray	USA	9.0	8.2	9.0	-	8.2	8.2	8.2
142	PI 418762	Afghanistan	9.0	8.2	9.0	8.2	-	-	-
143	PI 368524	Yugoslavia	9.0	8.2	9.0	8.0	8.3	-	-
144	PI 172798	Turkey	9.0	8.3	9.0	8.7	8.0	8.7	7.7
145	PI 240533	Iran	9.0	8.3	9.0	-	8.2	8.3	-
146	Dixielee	USA	9.0	8.3	9.0	8.7	8.3	7.8	-

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Table 2.1. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating			Maximum rating			
			Best	Average	Max.	Rep 1	Rep 2	Rep 3	Rep 4
147	Peacock WR 60	USA	9.0	8.3	9.0	8.2	8.7	8.0	-
148	PI 182183	Turkey	9.0	8.3	9.0	8.7	-	8.0	-
149	PI 207471	Afghanistan	9.0	8.3	9.0	8.0	-	8.7	-
150	PI 296335	S. Africa	9.0	8.3	9.0	-	-	-	8.3
151	PI 288316	India	9.0	8.3	9.0	-	8.3	-	-
152	Sugar Baby	USA	9.0	8.4	9.0	8.8	8.2	8.0	8.5
153	Allsweet	USA	9.0	8.5	9.0	8.5	8.5	8.2	8.7
154	PI 278038	Turkey	9.0	8.5	9.0	8.0	8.5	8.7	8.7
155	PI 357737	Yugoslavia	9.0	8.5	9.0	-	8.7	8.7	8.2
156	Calhoun Gray	USA	9.0	8.6	9.0	8.7	8.7	8.3	8.7
157	Crimson Sweet	USA	9.0	8.7	9.0	8.7	8.8	8.5	8.8
158	PI 274035	S. Africa	9.0	8.8	9.0	9.0	8.8	8.7	8.8
159	PI 357697	Yugoslavia	9.0	8.9	9.0	8.8	8.8	9.0	9.0
160	Grif 1728	China	-	-	-	-	-	-	-
161	PI 175657	Turkey	-	-	-	-	-	-	-
162	PI 176915	Turkey	-	-	-	-	-	-	-
163	PI 176923	Turkey	-	-	-	-	-	-	-
164	PI 181744	Lebanon	-	-	-	-	-	-	-
165	PI 183023	India	-	-	-	-	-	-	-
166	PI 185635	Ghana	-	-	-	-	-	-	-
167	PI 240532	Iran	-	-	-	-	-	-	-

(continued next page)

Table 2.1. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating			Maximum rating			
			Best	Average	Max.	Rep 1	Rep 2	Rep 3	Rep 4
168	PI 254429	Lebanon	-	-	-	-	-	-	-
169	PI 266027	Venezuela	-	-	-	-	-	-	-
170	PI 270524	Israel	-	-	-	-	-	-	-
171	PI 271468	India	-	-	-	-	-	-	-
172	PI 271767	S. Africa	-	-	-	-	-	-	-
173	PI 271770	S. Africa	-	-	-	-	-	-	-
174	PI 271771	S. Africa	-	-	-	-	-	-	-
175	PI 277983	Turkey	-	-	-	-	-	-	-
176	PI 277986	Turkey	-	-	-	-	-	-	-
177	PI 278010	Turkey	-	-	-	-	-	-	-
178	PI 278021	Turkey	-	-	-	-	-	-	-
179	PI 278030	Turkey	-	-	-	-	-	-	-
180	PI 278036	Turkey	-	-	-	-	-	-	-
181	PI 278049	Turkey	-	-	-	-	-	-	-
182	PI 278060	Turkey	-	-	-	-	-	-	-
183	PI 279456	Japan	-	-	-	-	-	-	-
184	PI 290855	USA	-	-	-	-	-	-	-
185	PI 314148	Former Soviet Union	-	-	-	-	-	-	-
186	PI 325248	Former Soviet Union	-	-	-	-	-	-	-
187	PI 344066	Turkey	-	-	-	-	-	-	-
188	PI 345545	Former Soviet Union	-	-	-	-	-	-	-

(continued next page)

Table 2.1. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Maximum rating Rep 1	Maximum rating Rep 2	Maximum rating Rep 3	Maximum rating Rep 4
189	PI 346787	USA	-	-	-	-	-	-	-
190	PI 357710	Yugoslavia	-	-	-	-	-	-	-
191	PI 357730	Yugoslavia	-	-	-	-	-	-	-
192	PI 357745	Yugoslavia	-	-	-	-	-	-	-
193	PI 385964	Kenya	-	-	-	-	-	-	-
194	PI 508443	S.Korea	-	-	-	-	-	-	-
195	PI 512393	Spain	-	-	-	-	-	-	-
196	PI 525081	Egypt	-	-	-	-	-	-	-
197	PI 532664	Switzerland	-	-	-	-	-	-	-
198	PI 534590	Syria	-	-	-	-	-	-	-
199	PI 549160	Chad	-	-	-	-	-	-	-
LSD (5%)			0.67	0.85	0.67	-	-	-	-

[z] Plants were rated on a scale of 0-9 on the basis of severity of viral symptoms, where 0=none, 1-2=trace, 3-4=slight, 5-6=moderate, 7-8=severe, and 9=plant dead. Best is the average of rating 3 for the 4 replications. Maximum is the average of rating 3 for all of the replications. Average is the overall average of all the ratings for all the replications.

Table 2.2. Plant-to-plant variation among cultigens differing in resistance to PRSV-W.

Cultigen name	Replication 1		Replication 2		Replication 3		Replication 4	
	Plant 1	Plant 2	Plant 1	Plant 2	Plant 1	Plant 2	Plant 1	Plant 2
PI 532699 [a]	6	6	5	6	6	7	6	-
PI 357697 [b]	9	9	9	9	9	9	9	9
Blackstone [c]	8	9	9	9	9	9	8	9
Crimson Sweet [d]	9	9	9	9	9	9	9	9

[a] PI accession randomly chosen among the most resistant.

[b] PI accessions randomly chosen among the most susceptible.

[c] Inbred cultivar tested for resistance to PRSV-W.

[d] Inbred cultivar used as susceptible check.

Chapter Three

Inheritance of *Papaya Ringspot Virus Watermelon Strain* Resistance in Watermelon

(In the format appropriate for submission to the Journal

of the American Society for Horticultural Science)

For: Journal of ASHS

Breeding and Genetics

Inheritance of *Papaya Ringspot Virus Watermelon Strain* Resistance in Watermelon

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Additional index words. Cucurbitaceae, *Citrullus lanatus*, mosaic, disease resistance, pathology, vegetable breeding

Received for publication _____. The research reported herein was funded in part by the North Carolina Agricultural Research Service. Use of trade names in this publication does not imply endorsement by the NCARS or the products named, or criticism of similar ones not mentioned.

Graduate research assistants, assistant professor, and professor, respectively. The authors gratefully acknowledge the technical assistance of Tammy L. Ellington.

For: Journal of ASHS

Breeding and Genetics

Inheritance of *Papaya Ringspot Virus Watermelon Strain* Resistance in Watermelon

Additional index words. Cucurbitaceae, Citrullus lanatus, mosaic, pathology, vegetable breeding, inheritance

Abstract

Sources of resistance to the watermelon strain of *Papaya ringspot virus* (PRSV-W) have been identified within the watermelon (*Citrullus lanatus*) germplasm collection. Inheritance of resistance to PRSV-W was studied in three *C. lanatus var. citroides* accessions: PI 244017, PI 244019, and PI 485583. Three susceptible parent lines, 'Allsweet', 'Calhoun Gray', and 'New Hampshire Midget', were crossed with resistant accessions to develop F1, F2, and BC1 generations for six families. A single recessive gene was found to control resistance to PRSV-W in all three resistant PI accessions. A test of allelism indicated that resistance to PRSV-W in the three PI accessions was due to the same gene. Therefore, the gene symbol '*prv*' is proposed for PRSV-W resistance in PI 244017, PI 244019, and PI 485583 in watermelon.

Watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai) is a major cucurbit crop that accounts for 7.5% of the world area devoted to vegetable crops (FAO, 2003). Worldwide, watermelons are grown on over 3.7 million ha, with a production of more than 83 million tons of fruit. China and the Middle Eastern countries are the major producers and consumers. In the United States, watermelon is used fresh as a dessert and in salads. Major production states in the U.S. are Florida, California, Texas, and Georgia (USDA, 2003). Production increased from 1.2 M tons in 1980 to 3.9 M tons in 2002, with a farm value of $329 million (USDA, 2003).

Plant diseases caused by viruses are a major limiting factor in commercial watermelon production worldwide. Around the world, over 10 viruses are known to be a problem in watermelon production (Provvidenti, 1986b). The major viruses affecting watermelon in the United States are *Papaya ringspot*

virus-watermelon strain (PRSV-W, formerly *Watermelon mosaic virus-1*), *Watermelon mosaic virus* (WMV, formerly *Watermelon mosaic virus-2*), and *Zucchini yellow mosaic virus* (ZYMV). All three viruses are non-persistently transmitted by a number of species of aphids, and mixed infections are common (Adlerz and Crall, 1967; Mohr, 1986; Provvidenti, 1991; Wehner et al., 2001). Virus diseases are destructive to the watermelon crop, and are difficult to control (Sherf and Macnab, 1986). Chemical control of the vectors is not usually efficient to control the disease. Cultural controls such as treatment with mineral oil sprays, light-reflective surfaces, and cross protection with weak PRSV-W isolates show limited effectiveness and require additional input costs. Therefore, genetic resistance remains the simplest, most effective and efficient means of limiting losses to these diseases (Provvidenti, 1993).

PRSV-W affects all agricultural species of the Cucurbitaceae and is of great economic importance because of its destructiveness (Provvidenti, 1993). PRSV-W was first described in 1965 by Webb and Scott (1965) from Asia in the region of the Indian subcontinent (Sri Lanka) (Bateson et al., 2002). PRSV-W was considered for a long time to be a distinct potyvirus, WMV-1 (Webb and Scott, 1965). However, the P and W isolates were found to be indistinguishable serologically (Gonsalves and Ishii, 1980) and now are considered to be strains of *Papaya ringspot virus* (Purcifull et al., 1984; Purcifull and Hiebert, 1979; Baker et al., 1991). The main reason for the early confusion about the taxonomic status of the W isolate was that it does not infect papaya. However, the P isolates infect cucurbits in nature as well as papaya (Provvidenti, 1993).

PRSV-W is transmitted in a non-persistent manner by 24 aphid species in 15 genera with *Myzus persicae, Aulacorthum solani, Aphis craccivora*, and *Macrosiphum euphorbiae* as natural vectors. PRSV-W is a potyvirus whose genome consists of unipartite, single-stranded, linear RNA. Its total genome size is 12 kb and codes for 8 proteins. PRSV-W is in the family *Potyviridae*. PRSV-W induce pinwheel and scroll types of cytoplasmic cylindrical inclusions in infected host cells (Purcifull et al., 1984). Type W isolates are reported to infect 38 species in 11 genera of Cucurbitaceae, and two species of Chenopodiaceae, with squash, watermelon, cucumber, and cantaloupe among the commercially important natural hosts. The virus is not seed transmitted. It appears to over winter in wild species of Cucurbitaceae and Chenopodiaceae (Purcifull and Hiebert, 1979).

Symptoms of severe PRSV-W infection in Cucurbits include mosaic, puckering, stunting, leaf blistering, leaf size reduction, and fruit that are small, knobby, greatly malformed, and mottled. PRSV-W causes significant yield reduction in watermelon, squash, melon, cucumber and other cultivated cucurbits (Provvidenti, 1993).

Researchers have screened cucurbit species other than watermelon for resistance to PRSV-W, and the inheritance of the resistance has been determined. Sources of resistance to PRSV-W have been found in cucumber (*Cucumis sativus*), melon (*Cucumis melo*), and squash (*Cucurbita* spp.). PRSV-W resistance is controlled by a single dominant gene in cucumber (Wai and Grumet, 1995) and a single dominant gene in melon (Pitrat and Lecoq, 1983). In squash, resistance to PRSV-W is controlled by a single recessive gene in *C. moschata* (Bolanos-Herrera, 1994) and three partially dominant genes in *C. maxima* (Maluf et al., 1997). Although sources of resistance to PRSV-W have been reported in watermelon, there has been no report of inheritance for resistance to PRSV-W in watermelon. The watermelon germplasm collection has been screened for resistance to PRSV-W. Strange et al. (2001) reported PRSV-W resistance in three PI accessions from South Africa (PI 244017, PI 244018, PI 244019), in three PI accessions from Zimbabwe (PI 482342, PI 482318, PI 482379), in one PI accession from Botswana (PI 485583) and in one PI accession from Nigeria (PI 595203). All of the resistant PI accessions except PI 595203 are *C. lanatus* var. *citroides*. PI 595203 is *C. lanatus* var. *lanatus.*

The objective of this study was to determine the genetic control of PRSV-W resistance in resistant PI accessions (PI 244017, PI 244019, and PI 485583) and to test the resistance genes for allelism.

Materials and Methods

Germplasm evaluated

The parental lines used in this study were watermelon cultivars Allsweet (ALS), New Hampshire Midget (NHM) and Calhoun Gray (CHG) that are highly susceptible to PRSV-W, and PI 244017, PI 244019, and PI 485583 that are highly resistant. Plant introduction (PI) accessions were obtained from the Southern Regional Plant Introduction Station at Griffin, Georgia. We used 'Allsweet', 'Calhoun Gray' and 'New Hampshire Midget' as susceptible parents because they have high fruit yield and quality (Wehner 2002). All crosses were made using controlled hand-pollination in the greenhouse of the Department of

Horticultural Science at North Carolina State University in Raleigh, NC. Six families were developed from six crosses, ALS x PI 244019, ALS x PI 485583, CHG x PI 244019, NHM x PI 244017, NHM x PI 244019, and NHM x PI 485583. The F_1 was self-pollinated and backcrossed to their respective parental lines, in order to obtain generations F_2, BC_1P_a and BC_1P_b for all six crosses. Each family contained six generations P_a, P_b, F_1, F_2, BC_1P_a, and BC_1P_b. For each of the six crosses, 180 plants were tested: 5 P_a, 5 P_b, 10 F_1, 100 F_2, 30 BC_1P_a, and 30 BC_1P_b plants were used to test the inheritance from each cross. Greenhouse temperatures ranged 23 to 43°C (day) and 12 to 24°C (night). The inheritance study was performed in the greenhouse of the department of Plant Pathology at North Carolina State University in Raleigh, NC under temperature conditions similar to those described above.

Virus culture and inoculation

The virus isolate was obtained from D.E. Purcifull, University of Florida, Gainesville. PRSV-W isolate 2052 was a severe isolate described by Baker et al. (1991) and was maintained on 'Gray Zucchini' squash (*Cucurbita pepo* L.) from Seminis Vegetable Seeds (Woodland, CA). The inoculation procedure used for increasing PRSV-W isolate in squash and for the inheritance experiment was the rub method (Guner et al., 2002). Inoculum was produced by grinding infected 'Gray Zucchini' leaves using mortar and pestle in 0.02 M phosphate buffer, pH 7.0. Leaf to buffer ratio was 1:5 (1 g infected leaf to 5 ml buffer). Inoculation consisted of dusting one leaf on each three-week-old plant with 800-mesh carborundum, then applying the inoculum to the leaf with a pestle which was rotated in a circular motion eight to ten times as if painting the leaf with inoculum. After inoculation, carborundum was rinsed off the leaves to improve light interception, and the plants were maintained in aphid-proof cages. All 'Gray Zucchini' plants were seeded in metromix 200 (Scotts-Sierra Horticultural Products Company, Marysville, OH) in 160 mm diameter (1550 ml volume) clay pots. Plants were fertilized weekly with 150 $mg.kg^{-1}$ Peters Professional 20-20-20 N-P-K (Scotts-Sierra Horticultural Products Company, Marysville, OH).

Plants were inoculated at the first true leaf stage, and rated two weeks after the inoculation on a scale of 1 to 9 on the basis of severity of viral symptoms, where 0=none, 1-2=trace, 3-4=slight, 5-6=moderate, 7-8=severe, and 9=plant dead (Guner et al, 2002).

Allelism

Tests were conducted to determine whether the resistance in three resistant PI accessions (PI 244017, PI 244019, and PI 485583) was allelic. The resistant PIs were crossed to each other in all possible combinations in the greenhouse. All F_1 hybrid derived from resistant x resistant crosses were inoculated with PRSV-W to determine allelism.

Data analysis

The chi-square tests for goodness-of-fit (Ramsey and Schafer, 1997) and homogeneity were used to examine segregation ratios in populations with the SAS statistical package (SAS Institute, Cary, NC) and the SAS Gene 1.2 program (Liu et al. 1997).

Results and Discussion

All crosses between susceptible parents and resistant parents produced uniformly susceptible F_1 progenies, indicating that PRSV-W resistance in crosses is a recessive trait. The F_2, BC_1P_a, and BC_1P_b segregation data for all six crosses were tested against the expected ratios for a single recessive gene. The F_2 segregation data obtained from all six crosses supported an expected 3 susceptible: 1 resistant ratio (Table 1). All BC_1P_a populations also supported the expected ratio for a single recessive gene hypothesis, showing 1 susceptible: 0 resistant ratio (Table 1). All BC_1P_b populations segregated 1 susceptible: 1 resistant ratio, which confirmed a single recessive gene (Table 1). The pooled F_2 individuals segregated 436 susceptible: 1154 resistant with a χ^2 of 0.35 (df=1) showing that the data were consistent with a 3:1 ratio. The P-value for that χ^2 also confirmed a good fit of the data to the predicted values (P-value=0.55) (Table 1). The homogeneity χ^2 (with df=5) for the F_2 was 0.99, indicating that all crosses represented the same population and were homogenous (Table 1).

Three PIs that are resistant to PRSV-W were tested for inheritance of PRSV-W in this study. Inheritance data indicated that resistance for PRSV-W in all three resistant PI accessions was controlled by a single recessive gene. However, we did not know that whether the resistance was allelic. In order to determine allelism, the resistant PI accessions were crossed in all possible combinations. However, we were able to get seeds from just three crosses: PI 244017 x PI 244019, PI 244017 x PI 244019, and PI 485583 x PI 244019. All F_1 were tested for resistance to PRSV-W using the same inoculation procedure

used in the inheritance study. All F_1 were resistant to PRSV-W, indicating that resistance in all three resistant PI accessions was allelic (Table 2).

We were able to get fruit set from some of the resistant x resistant crosses. The F_1 from PI 244019 x PI 244017, PI 244017 x PI 244018, and PI 244019 x PI 485583 were tested for resistance to PRSV-W. For each cross, we tested 15 F_1 plants. All of the F_1 plants showed resistance to PRSV-W, indicating that resistance in three resistant PI accessions was allelic. Our results from the inheritance study and allelism test confirm the hypothesis that PRSV-W resistance in PI 244017, PI 244019, and PI 485583 is controlled by the same single recessive gene. We propose naming this new gene Papaya ringspot virus resistance, with symbol *prv*, in conformance with gene nomenclature rules for Cucurbitaceae (Cucurbit Gene List Committee 1982).

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Table 3.1. Single locus goodness-of-fit-test for PRSV-W resistance in watermelon.

Generation	Total	Susceptible	Resistant	Expected[c]	χ^2	df	P-value
Allsweet x PI 244019							
P_a [a]	5	5	0				
P_b [b]	5	0	5				
F_1	10	10	0				
F_2	96	69	27	3:1	0.50	1	0.47
BC_1P_a	30	30	0				
BC_1P_b	29	14	15	1:1	0.03	1	0.85
Allsweet x PI 485583							
P_a [a]	5	5	0				
P_b [b]	5	0	5				
F_1	10	10	0				
F_2	97	73	24	3:1	0.00	1	0.95
BC_1P_a	27	27	0				
BC_1P_b	30	13	17	1:1	0.53	1	0.46
New Hampshire Midget x PI 244017							
P_a [a]	5	5	0				
P_b [b]	5	0	5				
F_1	10	10	0				
F_2	100	73	27	3:1	0.21	1	0.64
BC_1P_a	30	30	0				
BC_1P_b	30	16	14	1:1	0.13	1	0.71

(continued next page)

Table 3.1. (continued).

Generation	Total	Susceptible	Resistant	Expected[c]	χ^2	df	P-value
New Hampshire Midget x PI 244019							
P_a [a]	5	5	0				
P_b [b]	5	0	5				
F_1	10	10	0				
F_2	100	74	26	3:1	0.05	1	0.86
BC_1P_a	30	30	0				
BC_1P_b	30	18	12	1:1	1.20	1	0.27
New Hampshire Midget x PI 485583							
P_a [a]	5	5	0				
P_b [b]	5	0	5				
F_1	8	8	0				
F_2	100	72	28	3:1	0.48	1	0.48
BC_1P_a	29	29	0				
BC_1P_b	29	14	15	1:1	0.03	1	0.85
Calhoun Gray x PI 244019							
P_a [a]	4	4	0				
P_b [b]	5	0	5				
F_1	10	10	0				
F_2	97	75	24	3:1	0.28	1	0.59
BC_1P_a	30	30	0				
BC_1P_b	30	16	14	1:1	0.13	1	0.71

Table 3.2. Pooled and homogeneity data from all six crosses for resistance to PRSV-W in watermelon.

Generation	Total	Susceptible	Resistant	Expected[c]	χ^2	df	P-value
Pooled							
P_a [a]	29	29	0				
P_b [b]	30	0	30				
F_1	58	58	0				
F_2	590	436	154	3:1	0.35	1	0.55
BC_1P_a	176	176	0				
BC_1P_b	178	91	87	1:1	0.08	1	0.76
Homogeneity					1.18	5	0.99

[a] P_a was the susceptible parent

[b] P_b was the resistant parent

Expected[c] was the hypothesized segregation ratio for single gene inheritance

Chapter Four

Screening for Resistance to *Zucchini Yellow Mosaic Virus* in Watermelon

(In the format appropriate for submission to the Journal

of the American Society for Horticultural Science)

For: Journal of ASHS

Breeding and Genetics

Screening for Resistance to *Zucchini Yellow Mosaic Virus* in Watermelon

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Additional index words. Cucurbitaceae, *Citrullus lanatus*, zucchini yellow mosaic virus, inheritance, disease resistance, pathology, vegetable breeding

Received for publication _____. The research reported herein was funded in part by the North Carolina Agricultural Research Service. Use of trade names in this publication does not imply endorsement by the NCARS or the products named, or criticism of similar ones not mentioned.

Graduate research assistants, assistant professor, and professor, respectively. The authors gratefully acknowledge the technical assistance of Tammy L. Ellington.

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Breeding and Genetics

Screening for Resistance to *Zucchini Yellow Mosaic Virus* in Watermelon

Additional index words. Cucurbitaceae, *Citrullus lanatus*, zucchini yellow mosaic virus, inheritance, disease resistance, pathology, vegetable breeding

Abstract

The USDA germplasm collection of 1613 plant introduction (PI) accessions, as well as 41 watermelon cultivars, were screened for resistance to the Florida strain of *zucchini yellow mosaic virus* (ZYMV-FL). ZYMV infects all the agriculturally important species of the Cucurbitaceae and is one of the major virus diseases of watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai). Although there has been some screening for ZYMV resistance in watermelon, the crop has not been screened extensively for resistance. The objectives of this study were 1) to screen the U.S.D.A. watermelon germplasm collection for ZYMV resistance; 2) to verify the disease rating for the most resistant and most susceptible accessions; and 3) to determine the number of escapes based on a retest of the germplasm screening test. The experiment was a randomized complete block with four replications and 1654 accessions and cultivars. 'Charleston Gray' and 'Crimson Sweet' were used as susceptible checks to verify that the ZYMV inoculum was virulent. Cultigens were rated 0 to 9 for disease damage (0=none, 9=plant dead). Some of the accessions found to be resistant to PRSV-W (*Papaya ringspot virus watermelon strain*, formerly *Watermelon mosaic virus-2*) and WMV (*Watermelon mosaic virus*, formerly *Watermelon mosaic virus-2*) in past studies also showed some resistance to ZYMV. The PI accessions with the highest resistance (best rating 4.0 or less) to ZYMV were PI 595203, PI 386019, PI 490377, PI 596662, PI 560016, PI 494528, PI 386025, PI 595201, PI 494530, PI 485580, PI 386016, PI 494529, PI 386026, PI 482265, PI 585583, PI 244018, PI 386015, PI 482286, PI 482276, PI 596696, PI 596668, PI 596659, PI 596669, PI 596671, PI 386018, PI 244019, PI 482293, PI 559992, PI 485581, PI 595202, and PI 542119. The PI accessions with resistance to other watermelon viruses as well as ZYMV were PI 595203, PI 386015, PI 386016, PI

386024, PI 386025, PI 386026, PI 244018, PI 244019, PI 485583, and PI 494528, PI 494529. The retest of the most resistant 46 PI accessions showed that there were some escapes that were not resistant to ZYMV. Of the 46 resistant PI accessions in the retest, ten had resistance with a rating of 3.0 or less for the best, average and maximum ratings: PI 595203, PI 537277, PI 560016, PI 386016, PI 386019, PI 485580, PI 494529, PI 595200, PI 494528, PI 595201, PI 386025, PI 494530, PI 386015, PI 386021, PI 386026, and PI 596662. PI 595203 was the most resistant accession based on both the germplasm screening and the retest study.

Watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai) is a major cucurbit crop that accounts for 7.5% of the world area devoted to vegetable crops (FAO, 2003). There are 3.7 million ha of watermelon grown in the world, with China and the Middle Eastern countries the major producers and consumers. Watermelon is grown for its fruit that are usually eaten fresh, often as a dessert or in a fruit salad (Perkins-Veazie et al. 2001). U.S. production is concentrated in Florida, California, Texas, and Georgia (USDA, 2003), and increased from 1.2 M tons in 1980 to 3.9 M tons in 2003, with a farm value of $346 million (USDA, 2003).

Around the world, over 10 viruses are known to be a problem in watermelon production (Provvidenti, 1986b). Plant diseases caused by viruses are a major limiting factor in commercial watermelon production worldwide. The major viruses affecting watermelon in the United States are zucchini yellow mosaic virus (ZYMV), *Papaya ringspot virus-watermelon strain* (PRSV-W, formerly *Watermelon mosaic virus-1*), and *Watermelon mosaic virus* (WMV, formerly *Watermelon mosaic virus-2*) (Adlerz and Crall, 1967). Virus diseases are difficult to control. Watermelon fields may be infected with individual viruses, or with multiple viruses in combination. Virus diseases cause blotching and distortion of fruit that makes them unmarketable. These viruses can result in yield losses of 50 to 100% (Sherf and Macnab, 1986).

Major virus control methods include the use of insecticides, herbicides, reflective mulches, stylet oils, windbreaks, sequential plantings, avoiding seasons or locations with high aphid populations, and genetic resistance that is often pathogen-specific (Brown, 2001). Cultural controls show limited effectiveness and require additional input costs. Therefore, genetic resistance remains the simplest, most effective and

efficient means of limiting losses from virus diseases (Brown, 2001; ; Webb and Tyson. 1997; Sitterly 1973). Virus resistance has been found by screening germplasm collections, and has also been obtained through virus coat proteins transferred into useful cultivars (Namba et al., 1992; Quemada et al., 1990).

ZYMV is one of the more destructive viruses in watermelon production (Nameth et al., 1985). ZYMV infects all the agriculturally important species of the Cucurbitaceae (Provvidenti, 1991). ZYMV was first described in 1981 in squash growing in northern Italy (Lisa and Dellavalle, 1981). Within a decade, ZYMV had spread to the major cucurbit producing regions worldwide. Symptoms of severe ZYMV infection in *Cucurbita* include yellow mosaic, stunting, blistering and laminar reduction on leaves, and the development of knobby areas on fruit (Provvidenti, 1996). ZYMV causes significant yield reduction in squash, melon, watermelon, cucumber, and other cultivated cucurbits (Nameth et al., 1985). The severity of infection depends on the age of plants at infection, the strain of ZYMV involved, and the environment, particularly temperature (Desbiez and Lecoq, 1997).

ZYMV is a potyvirus with flexuous rods about 750 nm long, containing a single strand of RNA. At least 25 strains of ZYMV have been identified. They differ in virulence, symptom severity, and the ability to induce symptoms on plants carrying resistance genes. The major strains represented in the United States are referred to as the Connecticut strain (ZYMV-CT) and the Florida strain (ZYMV-FL) (Brown, 2001).

ZYMV is transmitted in a non-persistent manner by several aphid species, and is easily transmitted mechanically. The virus overwinters on wild species in areas where cucurbits are not grown. Along with the Cucurbitaceae, species in 11 families of dicotyledons are considered diagnostic hosts (Desbiez and Lecoq, 1997). Resistance to ZYMV has been found in cucumber, melon, watermelon, *Cucurbita moschata*, and wild *Cucurbita* species.

The watermelon germplasm collection has been screened for resistance to ZYMV, as well as other viruses. Plant introduction (PI) accessions were identified as resistant to ZYMV (Boyhan et al., 1992; Provvidenti, 1991), WMV (Gillaspie and Wright, 1993), and PRSV-W (Strange et al., 2001). Researchers have screened several of the cucurbit species for resistance to ZYMV, and the inheritance of resistance has been determined. Sources of resistance to ZYMV have been identified for cucumber (*Cucumis sativus*), melon (*Cucumis melo*), and squash (*Cucurbita* spp.). ZYMV resistance is controlled by a single recessive

gene in cucumber (Kabelka et al., 1997) and watermelon (Provvidenti, 1991), and by a single dominant gene in melon (Pitrat and Lecoq, 1984) and squash (Munger and Provvidenti, 1987; Paris et al., 1988; Gilbert-Albertini et al., 1993).

In the past, small collections of watermelon germplasm have been screened for resistance to ZYMV. Watermelon germplasm was first screened by Provvidenti, (1991), who used 68 PI accessions, breeding lines, and commercial cultivars. Provvidenti (1991) reported ZYMV resistance in four PI accessions from Zimbabwe (PI 482322, PI 482299, PI 482261, and PI 482308). That resistance was specific to the Florida strain of ZYMV (ZYMV-FL). Some accessions of the Nigerian Egusi watermelon (PI 494528 and PI 494532) were reported resistant to ZYMV, and were not viral strain specific (Provvidenti, 1986). However, that resistance was temperature dependent, usually expressed in warm or hot climates. Resistance in PI 482261 was conferred by a single recessive gene, *zym* (Provvidenti, 1991). Watermelon germplasm was also screened for ZYMV resistance by Boyhan et al. (1992) who tested 153 PI accessions, breeding lines, and commercial cultivars. They found new sources of resistance to ZYMV in PI 386026, 386025, and PI 595203 (*Citrullus lanatus* var. *lanatus*), formerly referred as Egun. They also confirmed the resistance of PI 482261 and PI 494528.

The watermelon germplasm collection at the Plant Genetic Resources Unit in Griffin, Georgia stores more than 1,600 watermelon PI accessions, with many accessions added since the initial screening for ZYMV was made in 1991. Also, recent seed increases have resulted in more PI accessions becoming available for researchers to evaluate. So far, 221 PI accessions, breeding lines and commercial cultivars have been screened for ZYMV resistance in the studies conducted by Provvidenti (1991) and by Boyhan et al. (1992), consisting of 14% of the USDA watermelon germplasm collection. It is a strong possibility that higher resistance to ZYMV can be identified by screening the other 86% of the watermelon germplasm collection. The identification of additional sources of resistance to ZYMV and the incorporation of this resistance into commercial cultivars would be desirable, since the initial sources of resistance are temperature dependent, or not resistant to some of the more severe strains in the collection.

The objectives of this study were: 1) to screen the U.S.D.A. watermelon germplasm collection along with available watermelon cultivars to identify additional sources of resistance to ZYMV; and 2) to verify

resistance of PI accessions that were identified previously. Accessions resistant to ZYMV will be identified for use in studies of inheritance and allelism, and for use in breeding programs to develop resistant cultivars.

Materials and Methods

Two experiments were performed: a germplasm screening and a retest of the most resistant and most susceptible cultigens. Experiments were run in the North Carolina State University Plant Pathology greenhouses. Greenhouse temperatures were 23 to 43°C during the day and 12 to 24°C during the night.

Germplasm Evaluated

All *Citrullus* plant introduction accessions were obtained from the Southern Regional Plant Introduction Station at Griffin, Georgia. PI accessions originated in 68 different countries, with 46 countries having fewer than 10 accessions each. Countries with the most accessions in the collection were Turkey (310), Yugoslavia (185), Zimbabwe (156), India (151), Spain (77), China (73), Zambia (68), South Africa (58), Nigeria (49), Iran (41), United States (33), and Syria (31).

Inoculation

The virus isolate was obtained from Dr. Ernest Hiebert, University of Florida, Gainesville. Three Florida isolates of ZYMV were tested initially to determine their virulence (data not shown). The ZYMV isolate used for screening was a subculture of isolate 2088, a severe isolate of ZYMV described by Wisler et al. (1995). The virus isolate was maintained on 'Gray Zucchini' squash (*Cucurbita pepo* L.) obtained from Seminis Vegetable Seeds (Woodland, California).

The inoculation procedure used for increasing the ZYMV isolate in squash and for the screening experiment was the leaf rub method (Guner et al., 2002). Inoculum was produced by grinding infected 'Gray Zucchini' squash leaves using a mortar and pestle in 0.02 M phosphate buffer, pH 7.0. Leaf to buffer ratio was 1:5 (1 g infected leaf to 5 ml buffer). Inoculation consisted of dusting one leaf on each three-week-old plant with 800-mesh carborundum, then applying the inoculum to the leaf with a pestle which was rotated in a circular motion eight to ten times as if painting the leaf with inoculum. After inoculation, carborundum was rinsed off the leaves to improve light interception, and the plants were maintained in aphid-proof cages. All 'Gray Zucchini' squash plants were seeded in metromix 200 (Scotts-Sierra

Horticultural Products Company, Marysville, OH) in 160 mm diameter (1550 ml volume) clay pots. Plants were fertilized weekly with 150 $mg.kg^{-1}$ Peters Professional 20-20-20 N-P-K (Scotts-Sierra Horticultural Products Company, Marysville, OH).

Germplasm screening

The germplasm screening was a randomized complete block with five replications of 1275 accessions. Each plot was a 100 x 100 mm square pot (600 ml volume) planted with two seeds and thinned to one plant before inoculation. In addition to the accessions tested, there were 50 check plants per replication of 'Charleston Gray' that were inoculated with the virus, and 50 check plants per replication of 'Charleston Gray' that were not inoculated. The inoculated checks served as verification of viral infection, and the uninoculated checks served as an indicator of other disease in the greenhouse that might confound symptom expression.

Traits evaluated

Plants were inoculated at the first true leaf stage, and rated weekly for a total of three weeks on a scale of 1 to 9 on the basis of severity of viral symptoms, where 0=none, 1-2=trace, 3-4=slight, 5-6=moderate, 7-8=severe, and 9=plant dead (Guner et al., 2002). After the second rating, plants which had not emerged at the time of inoculation were re-inoculated to reduce the number of escapes.

Retest

A retest was performed after the completion of the germplasm screening to verify the reaction of the most resistant and most susceptible accessions as well as to rescreen the missing cultigens. Missing cultigens were those that did not germinate at least in two replications during the germplasm screening study. The experiment was a randomized complete block with 4 replications of 98 cultigens along with one susceptible check ('Crimson Sweet'). Each plot was a 100 x 100 mm square pot (600 ml volume) planted with two seeds and thinned to one plant before inoculation. Plants were inoculated at the first true leaf stage, and rated weekly for three weeks starting two weeks after inoculation. Plants were rated on a scale of 0 to 9 the same as for the germplasm screening study. Data were analyzed and summarized the same as for the germplasm screening study.

Variability

Seeds of most PI accessions were originally collected from different locations around the world, some representing populations rather than inbred lines. Also, seeds of many accessions were increased in previous years by the plant introduction station using open pollination of accessions planted in rows. Therefore, PI accessions might be heterogeneous, with large differences from plant to plant. Data were checked to determine whether the PI accessions were more variable than the inbred cultivars. We used the standard deviation of individual replication data for the best rating as a measure of within-cultigen variability. If PI accessions were more variable than inbreds, more plants per accession should be screened for proper determination of their resistance.

Data analysis

Data were analyzed using the MEANS, ANOVA and GLM procedures of the SAS statistical package (SAS Institute, Cary, NC).

Results and Discussion

Germplasm screening

A total of 1654 accessions germinated in all four replications, and data were obtained for 1642 accessions. Twelve (0.7%) PI accessions did not germinate in all four replications: Grif 14201, Grif 14202, PI 271468, PI 271767, PI 274034, PI 381745, PI 386014, PI 532670, PI 542113, PI 542118, PI 596679, and PI 596691. There was no germination for 15 accessions in three replications, 26 accessions in two replications, and 89 accessions in one replication. However, 1513 (91.5%) PI accessions did germinate in all four replications. The complete dataset was submitted to the Germplasm Resources Information Network (http://www.ars-grin.gov/) for those interested in particular cultigens and also listed in appendix table 4. The most resistant and most susceptible cultigens are presented here along with the check cultivars (Table 4.1). The ANOVA indicated that there were highly significant differences (P=0.01) among accessions for all rating dates (Appendix table 3). Since the best and average ratings were highly correlated (r=0.95), and the maximum rating had a smaller F ratio than the other ratings, only the best rating was given in Table 4.1 to save space.

The best rating in the germplasm screening was rating 3 since it had the greatest range over cultigens relative to the LSD value. We used the best, average, and maximum ratings to identify the cultigens with the lowest values. There were 31 PI accessions that had a maximum rating of 4 or less (Table 4.1). In this study, we are reporting resistance to the severe isolate 2088 of ZYMV collected in Florida. However, resistant accessions may not be resistant to other isolates from Florida or other regions where ZYMV is found.

The issue of escapes is important in a large screening study such as this. Studies for resistance to WMV and PRSV-W found, during retest experiments, that some accessions that were initially rated resistant were actually just escapes. It is likely that some of the accessions reported to be resistant here could be escapes as well.

The susceptible checks used for this study were 'Charleston Gray' and 'Crimson Sweet', widely available cultivars. However, we identified accessions having more susceptibility to ZYMV than the checks. Some accessions would make excellent susceptible checks because they have high germination rates, and best ratings of 9.0 compared to 'Charleston Gray' and 'Crimson Sweet', which had best ratings of 8.3 and 8.8, respectively (Table 4.1). Any of the following accessions could be used as susceptible checks: PI 251244, PI 381752, PI 278058, PI 271987, PI 271750, PI 270143, PI 269679, PI 273480, PI 169241, and PI 182935 (data in GRIN).

The PI accessions with the most resistance (best rating 4.0 and less) along with complete data (missing in no more than one replication) were: PI 595203, PI 386019, PI 490377, PI 596662, PI 560016, PI 494528, PI 386025, PI 595201, PI 494530, PI 485580, PI 386016, PI 494529, PI 386026, PI 482265, PI 85583, PI 244018, PI 386015, PI 482286, PI 482276, PI 596696, PI 596668, PI 596659, PI 596669, PI 596671, PI 386018, PI 244019, PI 482293, PI 559992, PI 485581, PI 595202, and PI 542119 (Table 1).

As did previous researchers, we observed variation for virus resistance in the watermelon germplasm collection. Provvidenti (1991) and Boyhan et al. (1992) working with ZYMV, Gillaspie and Wright (1993) working with WMV and Strange et al. (2002) working with PRSV-W were able to identify resistant accessions in their watermelon research. Four PI accessions were found to be highly resistant to the Florida strain of ZYMV (ZYMV-FL) by Provvidenti (1991): PI 482308 (best rating of 4.5), PI 482299

(best rating of 5.5), PI 482322 (best rating of 5.3), and PI 482261 (best rating of 6.8). However, those accessions did not show high resistance in our study. Two Nigerian Egusi PI accessions also were found resistant to ZYMV by Provvidenti (1991): PI 494528 (best rating of 2.0) and PI 494532 (best rating of 7.7). However, in our study, PI 494532 was susceptible, while PI 494528 was highly resistant. PI accessions that were reported resistant to ZYMV by Boyhan et al. (1992) were also found resistant in our study. These were PI 386025 (best rating of 2.3), PI 386026 (best rating of 3.0), and PI 595203 (best rating of 0.5).

Some of the accessions found to be resistant to WMV and PRSV-W in previous studies also showed some resistance to ZYMV in our study. PI 595203 was found to be resistant to PRSV-W by Strange et al. (2002), to ZYMV-FL by Boyhan et al. (1992), to ZYMV-CH and WMV (personal communication, Xu Yong) and Gillaspie and Wright (1993). It was the most resistant to ZYMV in both our germplasm screening and retest studies. This PI accession appears to have high resistance to three viruses (ZYMV, WMV, and PRSV-W).

PI 189316, PI 189317, PI 189318, PI 255137, PI 164708, PI 306782, and PI 388770 were reported to be resistant to WMV by Gillaspie and Wright (1993), but showed no resistance to ZYMV in our study. On the other hand, PI 244018 (best rating of 3.3), PI 244019 (best rating of 3.8), PI 386016 (best rating of 2.5), PI 386024 (best rating of 5.0), PI 386025, PI 386026, and PI 595203 showed some resistance to ZYMV.

PI 244018, PI 244019, PI 482342 (best rating of 4.3), PI 485583 (best rating of 3.3), and PI 595203 were reported to be resistant to PRSV-W by Strange et al. (2002), and also had a high level of resistance to ZYMV. PI 482318 and PI 482379 also were reported to be resistant to PRSV-W, but were not resistant to ZYMV in our study. PI 244017 (best rating of 5.3) had the highest resistance to PRSV-W in the study by Strange et al. (2002) had intermediate resistance to ZYMV in our study. PI 386015 and PI 386016 were reported to be resistant to cucurbit yellow stunting disorder virus (CYSDV) by Lecoq et al. (1998), and also were resistant to ZYMV in our study.

Retest

The retest of the most resistant 46 PI accessions along with the check 'Crimson Sweet' showed that there were some escapes that were resistant to ZYMV in the screening study, but not in the retest study (Table 4.2). Seven PI accessions considered to be resistant in the germplasm screening, PI 482265, PI 482276, PI 482293, PI 490377, PI 542119, PI 559992, and PI 596669, were mostly rated intermediate or susceptible in the retest study. The PI accessions (missing in no more than one replication) with the most resistance (best rating less than 4.0 and less) were: PI 595203, PI 537277, PI 560016, PI 386016, PI 386019, PI 485580, PI 494529, PI 595200, PI 494528, PI 595201, PI 386025, PI 494530, PI 386015, PI 386021, PI 386026, and PI 596662, PI 596662, PI 386018, PI 595202, PI 244018, and PI 244019. PI 595203 was the most resistant cultigen based on data in both the germplasm screening and the retest study.

Susceptible PI accessions that were tested in the retest study had about the same level of susceptibility to ZYMV as in the germplasm screening (Table 4.2). PI 269679 was the most susceptible in the retest study and second most susceptible in the germplasm screening.

The 52 cultigens that did not germinate in at least two replications in the germplasm screening were included in the retest study. There, 19 out of 52 did not germinate in the retest study as well. Of those, 7 out of 12 (missing in all four replications) also did not germinate in all four replications in the retest study. None of the cultigens missing in all four replications of the screening study and then added to the retest study had a high level of resistance to ZYMV.

Variability

We expected many accessions to be heterogeneous since they were mostly collected in the wild and maintained by sib mating or open pollination. However, the most resistant and most susceptible accessions identified for further research were just as uniform as the check cultivars, which were inbred lines (Table 4.3).

If resistance were controlled by several genes, and accessions were segregating for resistance, the most resistant accession found in this study would not necessarily have the highest level of resistance possible. Resistance might be improved by intercrossing the most resistant accessions, or by crossing highly resistant accessions with moderately resistant ones.

PI accessions are often collected in the wild, and may be heterogeneous. Thus, accessions rated susceptible in this study may have a low frequency of resistant plants. Those could be identified by testing many plants per accession. It is also possible that resistant accessions have occasional susceptible plants in them. Thus, researchers and breeders should self pollinate and select the most resistant plants within the most resistant accessions to develop resistant inbred lines for further use.

Further research is needed to determine whether other isolates of ZYMV, such as ZYMV-CT and ZYMV-CH from different geographic regions react the same on the resistant and susceptible cultigens from this experiment. Additional research is needed to determine the inheritance of resistance to ZYMV in the resistant cultigens identified. Different sources of resistance need to be studied to determine whether resistance is controlled by allelic genes. The accessions with highest resistance to ZYMV should be used to develop inbred lines with the highest possible resistance for use in developing resistant cultivars.

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Table 4.1. Disease ratings for 1643 watermelon accessions inoculated with ZYMV in the screening study.[+]

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
Resistant									
1	PI 595203	USA	0.5	0.3	0.5	0.0	1.0	0.0	1.0
2	PI 386019	Iran	0.7	0.6	0.7	2.0	0.0	0.0	.
3	PI 490377	Mali	1.3	1.0	1.3	1.0	-	0.0	3.0
4	PI 596662	South_Africa	1.5	1.1	1.5	0.0	2.0	1.0	3.0
5	PI 560016	Nigeria	1.8	1.1	1.8	1.0	3.0	0.0	3.0
6	PI 494528	Nigeria	2.0	1.3	2.0	2.0	2.0	2.0	2.0
7	PI 386025	Iran	2.3	1.6	2.3	3.0	3.0	2.0	1.0
8	PI 595201	USA	2.3	1.7	2.3	3.0	3.0	1.0	2.0
9	PI 494530	Nigeria	2.3	1.9	2.3	3.0	3.0	0.0	3.0
10	PI 485580	Botswana	2.5	1.4	2.5	1.0	4.0	2.0	3.0
11	PI 386016	Iran	2.5	1.5	2.5	2.0	3.0	2.0	3.0
12	PI 494529	Nigeria	2.8	2.2	2.8	3.0	3.0	2.0	3.0
13	PI 386026	Iran	3.0	2.4	3.0	1.0	3.0	4.0	4.0
14	PI 482265	Zimbabwe	3.3	2.3	3.3	3.0	3.0	4.0	3.0
15	PI 485583	Botswana	3.3	2.3	3.3	3.0	4.0	2.0	4.0
16	PI 244018	South_Africa	3.3	2.7	3.3	3.0	3.0	5.0	2.0
17	PI 386015	Iran	3.3	2.8	3.3	4.0	3.0	3.0	3.0
18	PI 482286	Zimbabwe	3.3	2.8	3.3	3.0	4.0	3.0	3.0

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Table 4.1. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
19	PI 482276	Zimbabwe	3.5	2.3	3.5	3.0	4.0	3.0	4.0
20	PI 596696	South_Africa	3.5	2.4	3.5	4.0	4.0	3.0	3.0
21	PI 596668	S. Africa	3.5	3.0	3.5	4.0	3.0	3.0	4.0
22	PI 596659	S. Africa	3.5	3.1	3.5	3.0	3.0	4.0	4.0
23	PI 596669	South_Africa	3.7	3.1	3.7	.	4.0	3.0	4.0
24	PI 596671	South_Africa	3.8	3.1	3.8	3.0	4.0	3.0	5.0
25	PI 386018	Iran	3.8	3.2	3.8	4.0	3.0	3.0	5.0
26	PI 244019	South_Africa	3.8	3.3	3.8	4.0	3.0	4.0	4.0
27	PI 482293	Zimbabwe	4.0	3.0	4.0	4.0	4.0	4.0	4.0
28	PI 559992	Nigeria	4.0	3.1	4.0	4.0	5.0	4.0	3.0
29	PI 485581	Botswana	4.0	3.2	4.0	4.0	5.0	4.0	3.0
30	PI 595202	USA	4.0	3.3	4.0	3.0	4.0	5.0	4.0
31	PI 542119	Botswana	4.0	3.3	4.0	3.0	4.0	4.0	5.0
Checks									
1	Charleston Gray	U.S.-Louisiana	8.3	7.2	8.3	8.0	8.0	9.0	8.0
2	Crimson Sweet	U.S.-Kansas	8.8	7.8	8.8	9.0	9.0	8.0	9.0
Susceptible									
1	PI 251244	India	9.0	8.4	9.0	9.0	9.0	9.0	9.0
2	PI 381752	India	9.0	8.4	9.0	9.0	9.0	9.0	9.0

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Table 4.1. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
3	PI 278058	Turkey	9.0	8.4	9.0	9.0	9.0	9.0	9.0
4	PI 271987	Somalia	9.0	8.4	9.0	9.0	9.0	-	9.0
5	PI 271750	Ghana	9.0	8.6	9.0	9.0	-	9.0	9.0
6	PI 270143	India	9.0	8.8	9.0	-	9.0	-	9.0
7	PI 269679	Belize	9.0	9.0	9.0	9.0	9.0	9.0	9.0
8	PI 273480	Ethiopia	9.0	9.0	9.0	-	9.0	-	.
9	PI 169241	Turkey	9.0	8.3	9.0	9.0	9.0	9.0	9.0
10	PI 182935	India	9.0	8.3	9.0	9.0	9.0	9.0	9.0

[+]Plants were rated on a scale of 0 to 9 on the basis of severity of viral symptoms, where 0=none, 1-2=trace, 3-4=slight, 5-6=moderate, 7-8=severe, and 9=plant dead.

Table 4.2. Mean resistance ratings of the most resistant 46 and most susceptible 8 cultigens (along with check) of watermelon for ZYMV in the retest study.[+]

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
Resistant									
01	PI 595203	Nigeria	0.8	0.3	0.8	1.0	1.0	1.0	0.0
02	PI 537277	Pakistan	1.0	0.6	1.0	-	1.0	1.0	1.0
03	PI 560016	Nigeria	1.5	1.0	1.5	1.0	2.0	2.0	1.0
04	PI 386016	Iran	1.7	1.3	1.7	1.0	-	2.0	2.0
05	PI 386019	Iran	2.0	1.3	2.0	2.0	2.0	2.0	2.0
06	PI 485580	Botswana	2.3	1.7	2.3	2.0	3.0	2.0	2.0
07	PI 494529	Nigeria	2.3	1.8	2.3	2.0	2.0	3.0	2.0
08	PI 595200	Nigeria	2.3	1.8	2.5	2.0	3.0	3.0	1.0
09	PI 494528	Nigeria	2.3	1.9	2.3	2.0	3.0	2.0	.
10	PI 595201	Nigeria	2.5	1.6	2.5	2.0	3.0	3.0	2.0
11	PI 386025	Iran	2.5	1.9	2.5	2.0	3.0	2.0	3.0
12	PI 494530	Nigeria	2.5	2.0	2.5	2.0	3.0	3.0	2.0
13	PI 386015	Iran	2.5	2.0	2.5	2.0	2.0	3.0	3.0
14	PI 386021	Iran	2.7	2.1	2.7	3.0	3.0	2.0	.
15	PI 386026	Iran	2.7	2.1	2.7	3.0	-	2.0	3.0
16	PI 596662	South_Africa	3.0	2.4	3.0	2.0	3.0	3.0	4.0
17	PI 386018	Iran	3.8	3.0	3.8	4.0	4.0	4.0	3.0

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Table 4.2. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
18	PI 595202	Nigeria	3.8	3.2	3.8	4.0	3.0	4.0	4.0
19	PI 244018	South_Africa	4.0	3.2	4.0	4.0	4.0	4.0	4.0
20	PI 244019	S. Africa	4.0	3.4	4.0	4.0	4.0	4.0	4.0
21	PI 596696	S. Africa	4.3	3.5	4.3	4.0	5.0	4.0	4.0
22	PI 482286	Zimbabwe	4.5	3.5	4.5	5.0	4.0	4.0	5.0
23	PI 490377	Zimbabwe	4.7	3.7	4.7	-	4.0	5.0	5.0
24	PI 485583	Botswana	4.8	3.9	4.8	4.0	5.0	4.0	6.0
25	PI 596659	S. Africa	5.0	4.2	5.0	5.0	5.0	5.0	.
26	PI 596669	S. Africa	5.0	4.3	5.0	2.0	6.0	7.0	5.0
27	PI 271770	South_Africa	5.0	4.4	5.0	5.0	5.0	-	5.0
28	PI 485581	Botswana	5.3	4.6	5.3	5.0	6.0	6.0	4.0
29	PI 596668	South_Africa	5.5	4.4	5.5	6.0	6.0	5.0	5.0
30	PI 482276	Zimbabwe	5.8	4.8	5.8	6.0	6.0	6.0	5.0
31	PI 549161	Chad	5.8	4.9	5.8	5.0	5.0	7.0	6.0
32	PI 482265	Zimbabwe	5.8	5.0	5.8	5.0	7.0	6.0	5.0
33	PI 559992	Nigeria	5.8	5.0	5.8	6.0	6.0	7.0	4.0
34	PI 482342	Zimbabwe	5.8	5.1	5.8	6.0	5.0	7.0	5.0
35	PI 482309	Zimbabwe	5.8	5.3	5.8	5.0	5.0	8.0	5.0
36	PI 482308	Zimbabwe	6.0	5.2	6.0	6.0	7.0	6.0	5.0

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Table 4.2. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
37	PI 596666	South Africa	6.0	5.3	6.0	7.0	7.0	6.0	4.0
38	PI 482315	Zimbabwe	6.0	5.3	6.0	5.0	7.0	6.0	6.0
39	PI 482273	Zimbabwe	6.3	5.4	6.3	6.0	6.0	7.0	6.0
40	PI 500303	Zambia	6.3	5.4	6.3	6.0	6.0	7.0	6.0
41	PI 532659	Zimbabwe	6.3	5.6	6.3	5.0	7.0	7.0	6.0
42	PI 296334	South_Africa	6.3	5.6	6.3	6.0	8.0	6.0	5.0
43	PI 596671	S. Africa	6.3	5.6	6.3	6.0	6.0	7.0	.
44	PI 482293	Zimbabwe	6.5	5.6	6.5	7.0	8.0	6.0	5.0
45	PI 512385	Spain	6.8	6.1	6.8	7.0	7.0	7.0	6.0
46	PI 542119	Botswana	6.8	6.2	6.8	5.0	7.0	9.0	6.0
Susceptible									
1	PI 254429	Lebanon	8.7	8.0	8.7	-	9.0	9.0	8.0
2	PI 482336	Zimbabwe	8.7	8.2	8.7	8.0	9.0	9.0	.
3	PI 182935	India	8.8	8.2	8.8	8.0	9.0	9.0	9.0
4	PI 278058	Turkey	8.8	8.2	8.8	9.0	9.0	9.0	8.0
5	PI 269365	Afghanistan	8.8	8.3	8.8	9.0	9.0	8.0	9.0
6	PI 176492	Turkey	9.0	8.4	9.0	9.0	9.0	9.0	9.0
7	PI 270141	India	9.0	8.6	9.0	-	9.0	9.0	9.0
8	Grif 5601	India	9.0	8.6	9.0	9.0	-	9.0	9.0

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Table 4.2. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
9	PI 270143	India	9.0	8.7	9.0	9.0	9.0	9.0	9.0
10	PI 269679	Belize	9.0	8.8	9.0	9.0	9.0	9.0	.
Check									
Crimson Sweet		USA	8.7	8.2	8.7	-	8.0	9.0	9.0

[+] Analysis performed for means of each rating date plus the overall averages. Plants were rated on a scale of 0 to 9 on the basis of severity of viral symptoms, where 0=none, 1-2=trace, 3-4=slight, 5-6=moderate, 7-8=severe, and 9=plant dead. Average rating is the mean of the ratings of all 54 plants. Maximum rating is the mean of the final rating of all 54 plants per PI accession. Rank indicates the ranking of the cultigen for resistance to ZYMV, based on best rating (as well as average and maximum ratings; data not shown).

Table 4.3. Variation among replications for resistant and susceptible cultigens (along with 2 checks) of watermelon for ZYMV resistance using best rating for replications.[+]

Rank	Accession or cultivar	Country of origin	Virus rating over replication 1	2	3	4	5	6	7	8
Resistant										
1	PI 595203	USA	0.0	1.0	0.0	1.0	1.0	1.0	1.0	0.0
2	PI 494528	Nigeria	2.0	2.0	2.0	2.0	2.0	3.0	2.0	.
3	PI 244019	South Africa	4.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0
Checks										
1	Charleston. Gray	USA	8.0	8.0	9.0	8.0	-	-	-	-
2	Crimson Sweet	USA	9.0	9.0	8.0	9.0	.	8.0	9.0	9.0
Susceptible										
1	PI 270143	India	.	9.0	.	9.0	9.0	9.0	9.0	9.0
2	PI 269679	Belize	9.0	9.0	9.0	9.0	9.0	9.0	9.0	.
3	PI 182935	India	9.0	9.0	9.0	9.0	8.0	9.0	9.0	9.0

General Summary

Watermelon germplasm was screened for two potyviruses, *Papaya ring spot virus watermelon strain* (PRSV-W) and *Zucchini yellow mosaic virus* (ZYMV) and the inheritance of PRSV-W was determined. PI accessions screened in this study originated in 68 different countries. Countries with the most accessions in the collection were Turkey (296), Yugoslavia (163), Zimbabwe (122), India (120), Spain (71), Zambia (55), and South Africa (36). Most of the PI accessions that were found to be resistance to PRSV-W and ZYMV were from African countries such as Zimbabwe, Botswana, Nigeria, and South Africa which are the origin of the watermelon. Susceptible PIs were from several different countries located different regions in the world.

Several years of research has led the identification of PRSV-W resistant watermelon germplasm and will ultimately lead to the release of PRSV-W resistant watermelon cultivars. PI accessions found to be resistant to PRSV-W were PI 244017, PI 244019, PI 482342, PI 482318, PI 485583, PI 482379, PI 595203, and PI 244018. PI accessions with the highest resistance to PRSV-W that also showed resistance to other watermelon viruses (ZYMV and WMV) were PI 244018, PI 244019, PI 595203, PI 255137, and PI 482299. These would be the cultigen of choice to use in developing multiple virus resistant watermelon cultivars since they have multiple virus resistance that is of a high level. The cultigens were grown and inoculated with virus inoculum in vector free greenhouses. Resistant cultigens to PRSV-W have not been tested in under field conditions with natural vector (aphid) for inoculation and may not show resistance in field. They need to be tested for PRSV-W resistance under field conditions before their resistance was incorporated into watermelon cultivars and inbreds. We did not observe a necrotic hypersensitive response at the site of initial infection on these resistant cultigens.

A backcross breeding procedure could be easily utilized to incorporate PRSV-W resistance to watermelon cultivars and inbreds. Currently, this procedure is being used to incorporate PRSV-W resistance into several watermelon cultivars including 'Allsweet', 'Calhoun Gray', and 'New Hampshire Midget'.

An understanding of the inheritance of resistance to PRSV-W is essential for the development of resistant cultivars. Inheritance of PRSV-W resistance was studied in three *C. lanatus var. citroides*

accessions: PI 244017, PI 244019, and PI 485583. A single recessive gene was found to control resistance to PRSV-W in all three resistant cultigens. A test of allelism indicated that resistance to PRSV-W in the three cultigens were due to the same gene. Therefore, the gene symbol '*prv*' is proposed for PRSV-W resistance in PI 244017, PI 244019, and PI 485583 in watermelon. This is the first report in literature on the inheritance of PRSV-W resistance in watermelon.

Watermelon cultivars and the cultigens that were not screened in our previous study for resistance to PRSV-W were also screened for PRSV-W resistance. If any of watermelon cultivars posses resistance gene to PRSV-W, it would save tremendous time and effort for breeders to incorporate this resistance into other watermelon cultivars since they are already true to type. Although some watermelon cultivars are more resistant than others, none of them showed good level of resistance to PRSV-W. The cultigens that we screened did not have high level of resistance to PRSV-W. 'Verona' was more resistant cultivar among the watermelon cultivars, with a best rating of 7.0.

The USDA germplasm collection of 1613 PI accessions and 41 watermelon cultivars were screened for resistance to the Florida strain of *zucchini yellow mosaic virus.* Currently, there is no available commercial ZYMV resistant watermelon cultivars. This shows lack of high resistance ZYMV sources. Only 14% of watermelon germplasm was screened for ZYMV-FL in 1991 and 1992. Many accessions added since 1992. Also, recent seed increases have resulted in more PI accessions becoming available for researchers to evaluate. We screened and determined new resistance sources of ZYMV-FL in : PI 595203, PI 537277, PI 560016, PI 386016, PI 386019, PI 485580, PI 494529, PI 595200, PI 494528, and PI 595201.

Interestingly, PI 482261 that was reported resistant to ZYMV-FL did not show high level of resistance (best rating of 6.8) in our study. We have obtained our inoculum from different source than that the researcher who reported resistant in PI 482261. Resistant PIs that we determined in our study need to be tested with exact ZYMV-FL isolate that was used in screening of PI 482261 to determine their resistance.

Further research is needed to determine the inheritance of resistance to ZYMV-FL in the resistant cultigens identified in this study. Also, different sources of resistance need to be studied to determine

whether resistance is controlled by allelic genes. Most of the resistant PIs to ZYMV-FL were not available during our watermelon germplasm screening for PRSV-W resistance. Now we determined their resistance to PRSV-W but we do not know whether they are also resistant to ZYMV-FL or not. Those resistant PIs need to be tested for resistance to ZYMV-FL. Resistant PIs to both PRSV-W and ZYMV would be the cultigens of choice to use in developing multiple virus resistant watermelon cultivars.

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Appendix

Appendix table 1. Best resistance ratings of 1275 watermelon accessions inoculated with PRSV-W.[z]

	Accession	Seed	Virus rating			Best rating for replication				
Rank	name	source	Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
1	PI 278005	Turkey	3.0	9.0	5.3	-	3.0	3.0	-	-
2	PI 277972	Turkey	3.0	9.0	5.3	-	-	3.0	-	-
3	PI 278009	Turkey	3.0	9.0	5.3	-	-	3.0	-	-
4	PI 244017	S.Africa	3.4	6.8	4.7	5.0	3.0	2.0	3.0	4.0
5	PI 174104	Turkey	3.5	6.5	4.6	-	4.0	3.0	-	-
6	PI 164665	India	3.5	9.0	6.1	-	4.0	3.0	-	-
7	PI 164737	India	4.0	6.5	4.9	-	4.0	-	-	4.0
8	PI 244019	S.Africa	4.0	7.0	4.5	-	4.0	-	-	4.0
9	PI 244018	S.Africa	4.0	8.0	5.5	4.0	4.0	4.0	4.0	-
10	PI 278008	Turkey	4.0	9.0	4.8	4.0	-	-	-	-
11	PI 314655	Soviet Union	4.0	9.0	5.3	-	4.0	-	-	-
12	PI 277989	Turkey	4.0	9.0	5.5	-	4.0	-	-	-
13	PI 532667	Swaziland	4.0	9.0	6.2	-	-	4.0	-	-
14	PI 357752	Yugoslavia	4.0	9.0	6.2	-	4.0	-	-	-
15	PI 346082	Afghanistan	4.0	9.0	6.3	-	-	4.0	-	-
16	PI 482342	Zimbabwe	4.4	7.2	5.3	5.0	6.0	4.0	3.0	4.0
17	PI 277990	Turkey	4.5	9.0	5.7	-	5.0	4.0	-	-
18	PI 319212	Egypt	4.5	9.0	5.9	-	-	4.0	5.0	-
19	PI 234287	Portugal	4.8	8.0	5.7	4.0	4.0	-	5.0	6.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
20	PI 482303	Zimbabwe	4.8	8.6	5.7	4.0	4.0	2.0	9.0	5.0
21	PI 275628	Pakistan	5.0	7.2	5.6	5.0	3.0	4.0	9.0	4.0
22	PI 482261	Zimbabwe	5.0	8.2	6.1	5.0	5.0	2.0	9.0	4.0
23	PI 512364	Spain	5.0	9.0	5.8	-	4.0	-	-	6.0
24	PI 254742	Senegal	5.0	9.0	6.0	-	5.0	-	-	-
25	PI 177328	Turkey	5.0	9.0	6.0	4.0	3.0	9.0	4.0	-
26	PI 176489	Turkey	5.0	9.0	6.3	-	3.0	3.0	9.0	-
27	PI 271132	Tunisia	5.0	9.0	6.7	-	-	-	-	5.0
28	PI 485583	Botswana	5.2	6.8	5.4	4.0	5.0	4.0	9.0	4.0
29	PI 525086	Egypt	5.2	8.2	6.3	9.0	2.0	3.0	9.0	3.0
30	PI 195562	Ethiopia	5.3	9.0	6.1	-	4.0	4.0	9.0	4.0
31	PI 482322	Zimbabwe	5.3	9.0	6.4	9.0	4.0	4.0	4.0	-
32	PI 169232	Turkey	5.3	9.0	6.1	-	4.0	4.0	-	8.0
33	PI 169241	Turkey	5.3	9.0	6.6	-	4.0	3.0	9.0	-
34	PI 482318	Zimbabwe	5.4	9.0	5.8	6.0	4.0	2.0	9.0	6.0
35	PI 255137	S.Africa	5.5	7.5	5.5	6.0	-	3.0	9.0	4.0
36	PI 525088	Egypt	5.6	8.2	6.2	9.0	4.0	2.0	9.0	4.0
37	PI 595203	US, GA	5.6	8.2	6.2	8.0	4.0	9.0	4.0	3.0
38	PI 278058	Turkey	5.6	9.0	6.4	9.0	3.0	4.0	3.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
39	PI 482379	Zimbabwe	5.7	9.0	6.4	8.0	7.0	2.0	-	-
40	PI 345543	Soviet Union	5.7	9.0	6.6	-	-	4.0	4.0	9.0
41	PI 172803	Turkey	5.7	9.0	6.7	9.0	4.0	-	4.0	-
42	PI 278026	Turkey	5.7	9.0	6.9	-	3.0	5.0	9.0	-
43	PI 169238	Turkey	5.7	9.0	7.1	9.0	4.0	4.0	-	-
44	PI 271986	Somalia	5.7	9.0	7.2	-	5.0	3.0	9.0	-
45	PI 482315	Zimbabwe	5.8	9.0	6.6	-	5.0	9.0	5.0	4.0
46	PI 534592	Syria	5.8	9.0	6.7	-	4.0	3.0	9.0	7.0
47	PI 526235	Zimbabwe	5.8	9.0	6.8	9.0	4.0	5.0	-	5.0
48	PI 482299	Zimbabwe	5.8	7.0	6.1	5.0	7.0	9.0	4.0	4.0
49	PI 482305	Zimbabwe	5.8	8.2	6.9	9.0	3.0	4.0	9.0	4.0
50	PI 482269	Zimbabwe	5.8	9.0	6.8	7.0	6.0	3.0	9.0	4.0
51	PI 482312	Zimbabwe	5.8	9.0	6.9	7.0	6.0	9.0	3.0	4.0
52	PI 246559	Senegal	5.8	9.0	6.9	9.0	4.0	4.0	4.0	8.0
53	PI 248774	Namibia	6.0	6.3	5.8	5.0	-	9.0	-	4.0
54	PI 307609	Nigeria	6.0	8.0	6.9	9.0	5.0	4.0	9.0	3.0
55	PI 175663	Turkey	6.0	8.4	6.4	5.0	4.0	5.0	9.0	7.0
56	PI 250146	Pakistan	6.0	9.0	6.8	9.0	3.0	3.0	-	9.0
57	PI 482265	Zimbabwe	6.0	9.0	6.8	7.0	5.0	3.0	9.0	6.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
58	PI 379256	Yugoslavia	6.0	9.0	6.8	9.0	3.0	9.0	4.0	5.0
59	PI 177319	Turkey	6.0	9.0	6.8	-	-	-	-	6.0
60	PI 179881	India	6.0	9.0	7.0	9.0	4.0	3.0	9.0	5.0
61	PI 277976	Turkey	6.0	9.0	7.0	-	5.0	2.0	9.0	8.0
62	PI 278002	Turkey	6.0	9.0	7.1	-	3.0	-	9.0	-
63	PI 560006	Nigeria	6.0	9.0	7.1	7.0	5.0	3.0	9.0	-
64	PI 532668	cit. Swaziland	6.0	9.0	7.1	9.0	-	4.0	-	5.0
65	PI 595202	US, GA	6.0	9.0	7.2	7.0	6.0	4.0	4.0	9.0
66	PI 559994	Nigeria	6.0	9.0	7.2	9.0	3.0	3.0	-	9.0
67	PI 164639	India	6.0	9.0	7.3	-	5.0	4.0	9.0	-
68	PI 270525	Israel	6.0	9.0	7.7	-	-	3.0	9.0	-
69	PI 482309	Zimbabwe	6.2	7.4	6.2	4.0	5.0	9.0	9.0	4.0
70	PI 482326	Zimbabwe	6.2	9.0	7.0	9.0	6.0	4.0	4.0	8.0
71	PI 482272	Zimbabwe	6.2	9.0	7.1	7.0	3.0	4.0	9.0	8.0
72	PI 512349	Spain	6.2	9.0	7.1	9.0	5.0	3.0	5.0	9.0
73	PI 192938	China	6.2	9.0	7.2	9.0	4.0	5.0	9.0	4.0
74	PI 357679	Yugoslavia	6.3	8.0	6.8	-	3.0	9.0	9.0	4.0
75	PI 169249	Turkey	6.3	8.3	6.8	9.0	4.0	3.0	9.0	-
76	PI 172796	Turkey	6.3	9.0	6.5	-	4.0	3.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
77	PI 169279	Turkey	6.3	9.0	6.8	-	4.0	3.0	9.0	9.0
78	PI 208740	Cuba	6.3	9.0	6.9	8.0	5.0	4.0	-	8.0
79	PI 278042	Turkey	6.3	9.0	7.1	9.0	3.0	4.0	9.0	-
80	PI 482274	Zimbabwe	6.4	9.0	6.7	8.0	4.0	3.0	9.0	8.0
81	PI 534584	Syria	6.4	9.0	7.0	9.0	4.0	2.0	9.0	8.0
82	PI 274794	Pakistan	6.4	9.0	7.1	9.0	5.0	9.0	4.0	5.0
83	PI 482371	Zimbabwe	6.4	9.0	7.4	8.0	5.0	3.0	9.0	7.0
84	PI 269466	Pakistan	6.4	9.0	7.4	7.0	4.0	3.0	9.0	9.0
85	PI 482343	Zimbabwe	6.4	9.0	7.5	8.0	3.0	3.0	9.0	9.0
86	PI 274035	S. Africa	6.5	7.5	6.6	4.0	-	-	-	9.0
87	PI 254741	Senegal	6.5	7.8	6.8	9.0	5.0	9.0	-	3.0
88	PI 392291	Kenya	6.5	8.0	6.5	-	4.0	9.0	9.0	4.0
89	PI 502319	Uzbekistan	6.5	8.0	6.6	9.0	-	3.0	9.0	5.0
90	PI 193490	Ethiopia	6.5	8.0	7.0	9.0	4.0	-	9.0	4.0
91	PI 379223	Yugoslavia	6.5	8.5	6.9	9.0	5.0	9.0	-	3.0
92	PI 512369	Spain	6.5	8.5	6.9	9.0	4.0	-	9.0	4.0
93	PI 277987	Turkey	6.5	9.0	6.6	-	4.0	-	9.0	-
94	PI 278036	Turkey	6.5	9.0	6.6	-	4.0	9.0	-	-
95	PI 357681	Yugoslavia	6.5	9.0	6.8	9.0	-	-	4.0	-

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
96	PI 278061	Turkey	6.5	9.0	6.9	-	-	4.0	9.0	-
97	PI 177321	Turkey	6.5	9.0	7.0	9.0	4.0	-	-	-
98	PI 507865	Hungary	6.5	9.0	7.0	9.0	5.0	4.0	-	8.0
99	PI 277998	Turkey	6.5	9.0	7.0	-	4.0	-	9.0	-
100	PI 222184	Afghanistan	6.5	9.0	7.0	-	4.0	9.0	-	-
101	PI 278029	Turkey	6.5	9.0	7.0	9.0	9.0	3.0	5.0	-
102	PI 183023	India	6.5	9.0	7.2	-	4.0	-	9.0	-
103	PI 512345	Spain	6.5	9.0	7.2	-	4.0	-	-	9.0
104	PI 368499	Yugoslavia	6.5	9.0	7.2	9.0	5.0	-	3.0	9.0
105	PI 508445	S.Korea	6.5	9.0	7.3	-	8.0	4.0	9.0	5.0
106	PI 482280	Zimbabwe	6.5	9.0	7.3	9.0	4.0	4.0	-	9.0
107	PI 169289	Turkey	6.5	9.0	7.4	9.0	4.0	-	-	-
108	PI 482319	Zimbabwe	6.6	7.4	6.5	5.0	5.0	9.0	9.0	5.0
109	PI 537271	Pakistan	6.6	8.0	6.9	9.0	3.0	9.0	9.0	3.0
110	PI 512406	Spain	6.6	8.2	6.9	9.0	3.0	9.0	9.0	3.0
111	PI 270548	Ghana	6.6	8.4	7.1	9.0	5.0	2.0	9.0	8.0
112	PI 459075	Botswana	6.6	8.6	6.8	6.0	5.0	6.0	9.0	7.0
113	PI 526237	Zimbabwe	6.6	8.8	7.1	8.0	4.0	4.0	9.0	8.0
114	PI 278012	Turkey	6.6	9.0	6.9	9.0	4.0	3.0	9.0	8.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
115	PI 482264	Zimbabwe	6.6	9.0	7.0	8.0	4.0	9.0	4.0	8.0
116	PI 166993	Turkey	6.6	9.0	7.0	9.0	8.0	3.0	9.0	4.0
117	PI 370433	Yugoslavia	6.6	9.0	7.0	5.0	6.0	9.0	4.0	9.0
118	PI 482250	Zimbabwe	6.6	9.0	7.0	7.0	5.0	4.0	9.0	8.0
119	PI 381695	India	6.6	9.0	7.0	8.0	4.0	3.0	9.0	9.0
120	PI 518611	Soviet Union	6.6	9.0	7.1	8.0	4.0	9.0	3.0	9.0
121	PI 536448	Maldives	6.6	9.0	7.1	8.0	3.0	9.0	5.0	8.0
122	PI 415095	Honduras	6.6	9.0	7.2	9.0	4.0	3.0	9.0	8.0
123	PI 482346	Zimbabwe	6.6	9.0	7.2	8.0	4.0	4.0	9.0	8.0
124	PI 482256	Zimbabwe	6.6	9.0	7.3	8.0	4.0	9.0	3.0	9.0
125	PI 537465	Spain	6.6	9.0	7.3	9.0	4.0	2.0	9.0	9.0
126	PI 482276	Zimbabwe	6.6	9.0	7.4	9.0	5.0	2.0	9.0	8.0
127	PI 482273	Zimbabwe	6.6	9.0	7.4	8.0	5.0	2.0	9.0	9.0
128	PI 164474	India	6.6	9.0	7.4	9.0	4.0	3.0	9.0	8.0
129	PI 379231	Yugoslavia	6.6	9.0	7.5	9.0	4.0	2.0	9.0	9.0
130	PI 370424	Yugoslavia	6.6	9.0	7.5	8.0	4.0	3.0	9.0	9.0
131	PI 181743	Lebanon	6.6	9.0	7.5	9.0	3.0	4.0	9.0	8.0
132	PI 482292	Zimbabwe	6.6	9.0	7.5	7.0	5.0	3.0	9.0	9.0
133	PI 169262	Turkey	6.6	9.0	7.5	9.0	3.0	3.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
134	PI 193963	Ethiopia	6.6	9.0	7.6	8.0	4.0	3.0	9.0	9.0
135	PI 278014	Turkey	6.7	8.7	7.1	6.0	5.0	-	9.0	-
136	PI 278048	Turkey	6.7	9.0	6.9	-	2.0	9.0	9.0	-
137	PI 254430	Lebanon	6.7	9.0	6.9	-	8.0	4.0	-	8.0
138	PI 296339	S.Africa	6.7	9.0	7.2	7.0	4.0	-	-	9.0
139	PI 271752	Ghana	6.7	9.0	7.5	9.0	3.0	-	-	8.0
140	PI 169243	Turkey	6.8	8.0	6.5	5.0	4.0	-	9.0	9.0
141	PI 379229	Yugoslavia	6.8	8.0	6.8	5.0	9.0	4.0	9.0	-
142	PI 270546	Ghana	6.8	8.0	6.8	-	5.0	9.0	9.0	4.0
143	PI 379230	Yugoslavia	6.8	8.3	7.2	6.0	3.0	9.0	9.0	-
144	PI 534533	Syria	6.8	9.0	6.9	-	4.0	9.0	9.0	5.0
145	PI 435282	Iraq	6.8	9.0	7.0	9.0	4.0	9.0	-	5.0
146	PI 169284	Turkey	6.8	9.0	7.2	8.0	5.0	9.0	5.0	-
147	PI 172802	Turkey	6.8	9.0	7.3	9.0	4.0	9.0	-	5.0
148	PI 534532	Syria	6.8	9.0	7.4	8.0	7.0	3.0	9.0	-
149	PI 502317	Uzbekistan	6.8	9.0	7.4	-	6.0	4.0	9.0	8.0
150	PI 254736	Senegal	6.8	9.0	7.4	9.0	4.0	5.0	-	9.0
151	PI 271749	Afghanistan	6.8	9.0	7.4	9.0	-	9.0	4.0	5.0
152	PI 357726	Yugoslavia	6.8	9.0	7.4	9.0	4.0	-	9.0	5.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
153	PI 482267	Zimbabwe	6.8	9.0	7.4	9.0	5.0	4.0	9.0	-
154	PI 525084	Egypt	6.8	9.0	7.5	7.0	-	3.0	9.0	8.0
155	PI 288232	Egypt	6.8	9.0	7.5	9.0	5.0	4.0	-	9.0
156	PI 278045	Turkey	6.8	9.0	7.6	9.0	5.0	4.0	9.0	-
157	PI 526234	Zimbabwe	6.8	8.2	6.6	8.0	4.0	9.0	9.0	4.0
158	PI 482297	Zimbabwe	6.8	8.2	6.7	8.0	4.0	9.0	9.0	4.0
159	PI 536450	Maldives	6.8	8.2	7.0	9.0	4.0	9.0	9.0	3.0
160	PI 203551	USA, NM	6.8	8.4	6.7	9.0	4.0	9.0	3.0	9.0
161	PI 277995	Turkey	6.8	8.4	7.2	9.0	7.0	4.0	9.0	5.0
162	PI 537468	Spain	6.8	8.6	7.1	9.0	4.0	9.0	9.0	3.0
163	PI 512399	Spain	6.8	9.0	7.0	9.0	4.0	3.0	9.0	9.0
164	PI 482323	Zimbabwe	6.8	9.0	7.0	7.0	6.0	4.0	9.0	8.0
165	PI 500302	Zambia	6.8	9.0	7.1	9.0	8.0	4.0	9.0	4.0
166	PI 505593	Zambia	6.8	9.0	7.2	8.0	3.0	9.0	9.0	5.0
167	PI 167124	Turkey	6.8	9.0	7.2	9.0	3.0	4.0	9.0	9.0
168	PI 476326	Soviet Union	6.8	9.0	7.2	9.0	4.0	3.0	9.0	9.0
169	PI 512374	Spain	6.8	9.0	7.2	5.0	4.0	9.0	9.0	7.0
170	PI 526232	Zimbabwe	6.8	9.0	7.2	8.0	4.0	5.0	9.0	8.0
171	PI 169259	Turkey	6.8	9.0	7.4	9.0	4.0	9.0	4.0	8.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
172	PI 179876	India	6.8	9.0	7.4	9.0	4.0	3.0	9.0	9.0
173	PI 381728	India	6.8	9.0	7.4	9.0	4.0	4.0	9.0	8.0
174	PI 278040	Turkey	6.8	9.0	7.4	9.0	5.0	3.0	9.0	8.0
175	PI 482255	Zimbabwe	6.8	9.0	7.5	9.0	5.0	3.0	9.0	8.0
176	PI 482286	Zimbabwe	6.8	9.0	7.5	7.0	5.0	9.0	9.0	4.0
177	PI 534593	Syria	6.8	9.0	7.5	9.0	3.0	9.0	9.0	4.0
178	PI 500320	Zambia	6.8	9.0	7.5	8.0	3.0	5.0	9.0	9.0
179	PI 357748	Yugoslavia	6.8	9.0	7.6	9.0	5.0	2.0	9.0	9.0
180	PI 482285	Zimbabwe	6.8	9.0	7.6	9.0	5.0	5.0	9.0	6.0
181	PI 179235	Turkey	6.8	9.0	7.6	9.0	5.0	9.0	3.0	8.0
182	PI 482295	Zimbabwe	6.8	9.0	7.7	9.0	3.0	4.0	9.0	9.0
183	PI 379225	Yugoslavia	6.8	9.0	7.7	9.0	4.0	9.0	3.0	9.0
184	PI 163204	India	6.8	9.0	7.7	9.0	5.0	2.0	9.0	9.0
185	PI 536462	Maldives	6.8	9.0	7.7	9.0	4.0	3.0	9.0	9.0
186	PI 500313	Zambia	6.8	9.0	7.8	8.0	5.0	5.0	9.0	7.0
187	PI 175653	Turkey	6.8	9.0	7.8	9.0	5.0	2.0	9.0	9.0
188	PI 490376	Mali	7.0	8.0	6.3	5.0	9.0	9.0	-	5.0
189	PI 254624	Sudan	7.0	8.0	6.8	4.0	4.0	9.0	9.0	9.0
190	PI 271770	South Africa	7.0	8.0	7.4	5.0	-	9.0	-	-

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
191	PI 164687	India	7.0	8.2	6.8	4.0	4.0	9.0	9.0	9.0
192	PI 536449	Maldives	7.0	8.2	7.0	9.0	4.0	9.0	9.0	4.0
193	PI 482254	Zimbabwe	7.0	8.2	7.2	5.0	4.0	9.0	9.0	8.0
194	PI 482317	Zimbabwe	7.0	8.4	6.8	5.0	4.0	9.0	9.0	8.0
195	PI 174105	Turkey	7.0	8.4	6.9	4.0	5.0	9.0	9.0	8.0
196	PI 500316	Zambia	7.0	8.4	7.1	9.0	4.0	9.0	9.0	4.0
197	PI 176497	Turkey	7.0	8.4	7.4	9.0	4.0	9.0	9.0	4.0
198	PI 482278	Zimbabwe	7.0	8.8	7.1	6.0	5.0	9.0	9.0	6.0
199	PI 164248	Liberia	7.0	8.8	7.3	9.0	3.0	9.0	9.0	5.0
200	PI 505591	Zambia	7.0	8.8	7.3	8.0	5.0	9.0	9.0	4.0
201	PI 482249	Zimbabwe	7.0	9.0	7.0	9.0	3.0	9.0	9.0	5.0
202	PI 525096	Egypt	7.0	9.0	7.0	9.0	4.0	9.0	6.0	-
203	PI 482275	Zimbabwe	7.0	9.0	7.1	9.0	-	5.0	9.0	5.0
204	PI 482304	Zimbabwe	7.0	9.0	7.1	9.0	4.0	9.0	4.0	9.0
205	PI 482258	Zimbabwe	7.0	9.0	7.2	5.0	4.0	9.0	9.0	8.0
206	PI 175656	Turkey	7.0	9.0	7.2	9.0	4.0	9.0	9.0	4.0
207	PI 459074	Botswana	7.0	9.0	7.2	7.0	4.0	9.0	9.0	6.0
208	Grif 1729	China	7.0	9.0	7.2	-	7.0	-	9.0	5.0
209	PI 183123	India	7.0	9.0	7.2	9.0	6.0	9.0	4.0	-

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
210	PI 181741	Lebanon	7.0	9.0	7.3	8.0	7.0	3.0	9.0	8.0
211	PI 559999	Nigeria	7.0	9.0	7.3	9.0	5.0	3.0	9.0	9.0
212	PI 482336	Zimbabwe	7.0	9.0	7.3	-	5.0	9.0	-	-
213	PI 525091	Egypt	7.0	9.0	7.4	9.0	4.0	9.0	9.0	4.0
214	PI 174103	Turkey	7.0	9.0	7.4	9.0	8.0	4.0	5.0	9.0
215	PI 549160	Chad	7.0	9.0	7.4	7.0	-	-	-	-
216	PI 274795	Pakistan	7.0	9.0	7.4	9.0	4.0	4.0	9.0	9.0
217	PI 222715	Iran	7.0	9.0	7.4	9.0	5.0	-	-	-
218	PI 500301	Zambia	7.0	9.0	7.4	9.0	4.0	4.0	9.0	9.0
219	PI 172794	Turkey	7.0	9.0	7.4	9.0	4.0	4.0	9.0	9.0
220	PI 314236	Soviet Union	7.0	9.0	7.4	9.0	4.0	4.0	9.0	9.0
221	PI 169247	Turkey	7.0	9.0	7.5	9.0	5.0	3.0	9.0	9.0
222	PI 357729	Yugoslavia	7.0	9.0	7.5	9.0	4.0	-	-	8.0
223	PI 505587	Zambia	7.0	9.0	7.5	7.0	5.0	9.0	9.0	5.0
224	PI 482296	Zimbabwe	7.0	9.0	7.5	7.0	6.0	4.0	9.0	9.0
225	PI 190050	Yugoslavia, Serbia	7.0	9.0	7.5	9.0	6.0	3.0	9.0	8.0
226	PI 183218	Egypt	7.0	9.0	7.5	-	5.0	-	9.0	7.0
227	PI 536453	Maldives	7.0	9.0	7.5	9.0	6.0	2.0	9.0	9.0
228	PI 278019	Turkey	7.0	9.0	7.5	9.0	6.0	9.0	4.0	-

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
229	PI 195771	Guatemala	7.0	9.0	7.5	6.0	5.0	9.0	9.0	6.0
230	PI 186490	Nigeria	7.0	9.0	7.5	9.0	4.0	9.0	9.0	4.0
231	PI 482325	Zimbabwe	7.0	9.0	7.5	7.0	5.0	5.0	9.0	9.0
232	PI 537470	Spain	7.0	9.0	7.5	9.0	4.0	4.0	9.0	9.0
233	PI 357668	Yugoslavia	7.0	9.0	7.6	9.0	5.0	-	9.0	5.0
234	PI 368520	Yugoslavia	7.0	9.0	7.6	9.0	5.0	-	-	-
235	PI 368530	Yugoslavia	7.0	9.0	7.6	9.0	4.0	4.0	9.0	9.0
236	PI 381716	India	7.0	9.0	7.6	9.0	4.0	9.0	9.0	4.0
237	PI 269465	Pakistan	7.0	9.0	7.6	9.0	3.0	9.0	5.0	9.0
238	PI 212983	India	7.0	9.0	7.6	9.0	4.0	9.0	9.0	4.0
239	PI 169248	Turkey	7.0	9.0	7.7	9.0	3.0	-	9.0	-
240	PI 512386	Spain	7.0	9.0	7.7	9.0	3.0	9.0	9.0	5.0
241	PI 381719	India	7.0	9.0	7.7	9.0	6.0	3.0	9.0	8.0
242	PI 370429	Yugoslavia	7.0	9.0	7.7	9.0	5.0	5.0	9.0	-
243	PI 177331	Israel	7.0	9.0	7.7	9.0	-	3.0	9.0	-
244	PI 368506	Yugoslavia	7.0	9.0	7.7	9.0	4.0	9.0	9.0	4.0
245	PI 476328	Soviet Union	7.0	9.0	7.7	5.0	4.0	9.0	9.0	8.0
246	PI 178874	Turkey	7.0	9.0	7.7	6.0	8.0	4.0	9.0	8.0
247	PI 379257	Yugoslavia	7.0	9.0	7.8	9.0	4.0	4.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
248	PI 176906	Turkey	7.0	9.0	7.8	9.0	4.0	4.0	9.0	9.0
249	PI 296335	S.Africa	7.0	9.0	7.8	7.0	-	-	-	-
250	PI 277997	Turkey	7.0	9.0	7.8	9.0	3.0	-	9.0	-
251	PI 357718	Yugoslavia	7.0	9.0	7.8	-	5.0	9.0	-	-
252	PI 595219	USA	7.0	9.0	7.9	8.0	4.0	-	-	9.0
253	PI 177326	Turkey	7.0	9.0	7.9	9.0	3.0	9.0	9.0	5.0
254	PI 175655	Turkey	7.0	9.0	7.9	9.0	3.0	-	9.0	-
255	PI 229605	Iran	7.0	9.0	7.9	9.0	5.0	-	-	-
256	PI 491265	Zimbabwe	7.2	8.2	6.9	9.0	5.0	9.0	9.0	4.0
257	PI 177329	Turkey	7.2	8.2	7.1	4.0	5.0	9.0	9.0	9.0
258	PI 176909	Turkey	7.2	8.6	7.1	9.0	4.0	5.0	9.0	9.0
259	PI 482308	Zimbabwe	7.2	9.0	7.0	5.0	8.0	9.0	9.0	5.0
260	PI 174098	Turkey	7.2	9.0	7.2	9.0	5.0	4.0	9.0	9.0
261	PI 381733	India	7.2	9.0	7.2	9.0	4.0	9.0	9.0	5.0
262	PI 500315	Zambia	7.2	9.0	7.4	8.0	8.0	3.0	9.0	8.0
263	PI 494821	Zambia	7.2	9.0	7.4	7.0	3.0	9.0	9.0	8.0
264	PI 169297	Turkey	7.2	9.0	7.5	9.0	8.0	3.0	9.0	7.0
265	PI 537467	Spain	7.2	9.0	7.5	9.0	4.0	9.0	9.0	5.0
266	PI 505588	Zambia	7.2	9.0	7.5	9.0	6.0	3.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
267	PI 171581	Turkey	7.2	9.0	7.5	3.0	6.0	9.0	9.0	9.0
268	PI 271779	S.Africa	7.2	9.0	7.5	9.0	5.0	4.0	9.0	9.0
269	PI 537266	Pakistan	7.2	9.0	7.5	9.0	6.0	3.0	9.0	9.0
270	PI 357668	Yugoslavia	7.0	9.0	7.6	9.0	5.0	-	9.0	5.0
271	PI 368520	Yugoslavia	7.0	9.0	7.6	9.0	5.0	-	-	-
272	PI 368530	Yugoslavia	7.0	9.0	7.6	9.0	4.0	4.0	9.0	9.0
273	PI 381716	India	7.0	9.0	7.6	9.0	4.0	9.0	9.0	4.0
274	PI 269465	Pakistan	7.0	9.0	7.6	9.0	3.0	9.0	5.0	9.0
275	PI 212983	India	7.0	9.0	7.6	9.0	4.0	9.0	9.0	4.0
276	PI 169248	Turkey	7.0	9.0	7.7	9.0	3.0	-	9.0	-
277	PI 512386	Spain	7.0	9.0	7.7	9.0	3.0	9.0	9.0	5.0
278	PI 381719	India	7.0	9.0	7.7	9.0	6.0	3.0	9.0	8.0
279	PI 370429	Yugoslavia	7.0	9.0	7.7	9.0	5.0	5.0	9.0	-
280	PI 177331	Israel	7.0	9.0	7.7	9.0	-	3.0	9.0	-
281	PI 368506	Yugoslavia	7.0	9.0	7.7	9.0	4.0	9.0	9.0	4.0
282	PI 476328	Soviet Union	7.0	9.0	7.7	5.0	4.0	9.0	9.0	8.0
283	PI 178874	Turkey	7.0	9.0	7.7	6.0	8.0	4.0	9.0	8.0
284	PI 379257	Yugoslavia	7.0	9.0	7.8	9.0	4.0	4.0	9.0	9.0
285	PI 176906	Turkey	7.0	9.0	7.8	9.0	4.0	4.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
286	PI 296335	S.Africa	7.0	9.0	7.8	7.0	-	-	-	-
287	PI 277997	Turkey	7.0	9.0	7.8	9.0	3.0	-	9.0	-
288	PI 357718	Yugoslavia	7.0	9.0	7.8	-	5.0	9.0	-	-
289	PI 595219	USA	7.0	9.0	7.9	8.0	4.0	-	-	9.0
290	PI 177326	Turkey	7.0	9.0	7.9	9.0	3.0	9.0	9.0	5.0
291	PI 175655	Turkey	7.0	9.0	7.9	9.0	3.0	-	9.0	-
292	PI 229605	Iran	7.0	9.0	7.9	9.0	5.0	-	-	-
293	PI 491265	Zimbabwe	7.2	8.2	6.9	9.0	5.0	9.0	9.0	4.0
294	PI 177329	Turkey	7.2	8.2	7.1	4.0	5.0	9.0	9.0	9.0
295	PI 176909	Turkey	7.2	8.6	7.1	9.0	4.0	5.0	9.0	9.0
296	PI 482308	Zimbabwe	7.2	9.0	7.0	5.0	8.0	9.0	9.0	5.0
297	PI 381707	India	7.2	9.0	7.8	9.0	6.0	3.0	9.0	9.0
298	PI 379249	Yugoslavia	7.3	8.8	7.1	8.0	-	4.0	9.0	8.0
299	PI 164247	Nigeria	7.3	8.8	7.2	6.0	5.0	9.0	-	9.0
300	PI 370430	Yugoslavia	7.3	9.0	7.2	-	3.0	9.0	9.0	8.0
301	PI 500328	Zambia	7.3	9.0	7.2	-	3.0	9.0	9.0	8.0
302	PI 226506	Iran	7.3	9.0	7.3	9.0	2.0	-	9.0	9.0
303	PI 381722	India	7.3	9.0	7.4	-	3.0	9.0	9.0	8.0
304	PI 526231	Zimbabwe	7.3	9.0	7.5	6.0	-	9.0	9.0	5.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
305	PI 228237	Israel	7.3	9.0	7.5	9.0	3.0	-	9.0	8.0
306	PI 177322	Turkey	7.3	9.0	7.5	-	6.0	9.0	9.0	5.0
307	PI 357725	Yugoslavia	7.3	9.0	7.5	9.0	7.0	4.0	-	9.0
308	PI 357722	Yugoslavia	7.3	9.0	7.5	-	7.0	9.0	9.0	4.0
309	PI 164685	India	7.3	9.0	7.6	9.0	3.0	-	9.0	8.0
310	PI 357742	Yugoslavia	7.3	9.0	7.7	9.0	-	3.0	9.0	8.0
311	PI 222137	Algeria	7.3	9.0	7.7	9.0	3.0	9.0	-	8.0
312	PI 357674	Yugoslavia	7.3	9.0	7.8	8.0	3.0	9.0	9.0	-
313	PI 534595	Syria	7.3	7.7	7.2	-	-	9.0	9.0	4.0
314	PI 165523	India	7.3	7.7	7.2	4.0	-	9.0	9.0	-
315	PI 357702	Yugoslavia	7.3	8.7	7.4	4.0	-	9.0	-	9.0
316	PI 183300	India	7.3	9.0	7.3	9.0	4.0	9.0	-	-
317	PI 357693	Yugoslavia	7.3	9.0	7.3	9.0	5.0	-	-	8.0
318	PI 277994	Turkey	7.3	9.0	7.4	9.0	4.0	9.0	-	-
319	PI 379228	Yugoslavia	7.3	9.0	7.4	9.0	9.0	-	-	4.0
320	PI 278000	Turkey	7.3	9.0	7.4	-	5.0	-	9.0	8.0
321	PI 177320	Turkey	7.3	9.0	7.5	9.0	-	-	5.0	8.0
322	PI 556995	USA	7.3	9.0	7.5	-	4.0	9.0	9.0	-
323	PI 357695	Yugoslavia	7.3	9.0	7.6	-	4.0	-	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
324	PI 441722	Brazil	7.3	9.0	7.6	-	4.0	9.0	9.0	-
325	PI 368503	Yugoslavia	7.3	9.0	7.6	9.0	-	-	9.0	4.0
326	PI 211915	Iran	7.3	9.0	7.6	9.0	-	4.0	-	9.0
327	PI 357712	Yugoslavia	7.3	9.0	7.6	9.0	5.0	-	-	8.0
328	PI 490381	Mali	7.3	9.0	7.6	9.0	4.0	-	9.0	-
329	PI 182175	Turkey	7.3	9.0	7.7	9.0	4.0	-	-	9.0
330	PI 357754	Yugoslavia	7.3	9.0	7.7	9.0	-	-	9.0	4.0
331	PI 357711	Yugoslavia	7.3	9.0	7.7	9.0	4.0	-	9.0	-
332	PI 357660	Yugoslavia	7.3	9.0	7.8	9.0	4.0	-	9.0	-
333	PI 519612	Soviet Union	7.3	9.0	7.8	-	4.0	-	9.0	9.0
334	PI 357703	Yugoslavia	7.3	9.0	7.9	-	4.0	-	9.0	9.0
335	PI 278017	Turkey	7.3	9.0	7.9	-	4.0	9.0	9.0	-
336	PI 270522	Hungary	7.3	9.0	8.1	9.0	-	4.0	9.0	-
337	PI 182932	India	7.3	9.0	8.4	9.0	-	4.0	9.0	-
338	PI 163203	India	7.4	8.2	7.5	5.0	5.0	9.0	9.0	9.0
339	PI 535948	Cameroon	7.4	8.4	7.0	8.0	6.0	9.0	9.0	5.0
340	PI 172797	Turkey	7.4	8.4	7.6	9.0	6.0	9.0	9.0	4.0
341	PI 494531	Nigeria	7.4	8.8	7.5	5.0	5.0	9.0	9.0	9.0
342	PI 502315	Ukraine	7.4	9.0	7.2	5.0	5.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
343	PI 482316	Zimbabwe	7.4	9.0	7.3	7.0	4.0	9.0	9.0	8.0
344	PI 526239	Zimbabwe	7.4	9.0	7.3	7.0	4.0	9.0	9.0	8.0
345	PI 487458	Venezuela	7.4	9.0	7.3	9.0	2.0	9.0	9.0	8.0
346	PI 494816	Zambia	7.4	9.0	7.3	7.0	4.0	9.0	9.0	8.0
347	PI 482341	Zimbabwe	7.4	9.0	7.4	8.0	3.0	9.0	9.0	8.0
348	PI 507862	Hungary	7.4	9.0	7.4	9.0	8.0	3.0	9.0	8.0
349	PI 183398	India	7.4	9.0	7.4	4.0	7.0	9.0	9.0	8.0
350	PI 482357	Zimbabwe	7.4	9.0	7.4	7.0	4.0	9.0	9.0	8.0
351	PI 534585	Syria	7.4	9.0	7.5	8.0	4.0	9.0	9.0	7.0
352	PI 482251	Zimbabwe	7.4	9.0	7.5	7.0	4.0	9.0	9.0	8.0
353	PI 381731	India	7.4	9.0	7.5	9.0	8.0	2.0	9.0	9.0
354	PI 381701	India	7.4	9.0	7.5	9.0	5.0	9.0	9.0	5.0
355	PI 172788	Turkey	7.4	9.0	7.6	9.0	3.0	9.0	9.0	7.0
356	PI 482350	Zimbabwe	7.4	9.0	7.6	8.0	3.0	9.0	9.0	8.0
357	PI 512376	Spain	7.4	9.0	7.6	9.0	8.0	3.0	9.0	8.0
358	Grif 1730	China	7.4	9.0	7.6	7.0	4.0	9.0	9.0	8.0
359	PI 482306	Zimbabwe	7.4	9.0	7.6	7.0	4.0	9.0	9.0	8.0
360	PI 184800	Nigeria	7.4	9.0	7.7	9.0	4.0	9.0	9.0	6.0
361	PI 381698	India	7.4	9.0	7.7	9.0	3.0	9.0	9.0	7.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
362	PI 512397	Spain	7.4	9.0	7.7	9.0	6.0	4.0	9.0	9.0
363	PI 525098	Egypt	7.4	9.0	7.7	8.0	3.0	9.0	9.0	8.0
364	PI 175658	Turkey	7.4	9.0	7.7	9.0	3.0	9.0	9.0	7.0
365	PI 534586	Syria	7.4	9.0	7.8	9.0	5.0	9.0	9.0	5.0
366	PI 175664	Turkey	7.4	9.0	7.9	9.0	4.0	9.0	9.0	6.0
367	PI 164543	India	7.4	9.0	7.9	9.0	7.0	3.0	9.0	9.0
368	PI 229604	Iran	7.4	9.0	7.9	9.0	5.0	9.0	9.0	5.0
369	PI 512347	Spain	7.4	9.0	7.9	9.0	5.0	5.0	9.0	9.0
370	PI 164636	India	7.4	9.0	7.9	9.0	4.0	9.0	9.0	6.0
371	PI 176498	Turkey	7.5	7.5	7.2	6.0	-	9.0	-	-
372	PI 254623	Sudan	7.5	8.3	7.5	9.0	-	9.0	3.0	9.0
373	PI 278023	Turkey	7.5	9.0	7.0	9.0	4.0	-	9.0	8.0
374	PI 279459	Japan	7.5	9.0	7.1	9.0	6.0	9.0	-	6.0
375	PI 172795	Turkey	7.5	9.0	7.2	9.0	3.0	-	9.0	9.0
376	PI 211850	Iran	7.5	9.0	7.4	9.0	4.0	9.0	-	8.0
377	PI 299378	S.Africa	7.5	9.0	7.4	-	6.0	-	-	9.0
378	PI 271133	Tunisia	7.5	9.0	7.5	9.0	3.0	9.0	-	9.0
379	PI 183124	India	7.5	9.0	7.5	9.0	4.0	-	9.0	8.0
380	PI 165024	Turkey	7.5	9.0	7.6	-	3.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
381	PI 175657	Turkey	7.5	9.0	7.6	-	6.0	-	9.0	-
382	PI 278001	Turkey	7.5	9.0	7.6	9.0	-	9.0	3.0	9.0
383	PI 242906	Afghanistan	7.5	9.0	7.6	-	3.0	9.0	9.0	9.0
384	PI 296332	S.Africa	7.5	9.0	7.6	-	3.0	9.0	9.0	9.0
385	PI 278037	Turkey	7.5	9.0	7.7	9.0	3.0	9.0	-	9.0
386	PI 357739	Yugoslavia	7.5	9.0	7.7	-	-	9.0	-	6.0
387	PI 526233	Zimbabwe	7.5	9.0	7.7	-	3.0	9.0	9.0	9.0
388	PI 370426	Yugoslavia	7.5	9.0	7.7	-	3.0	9.0	9.0	9.0
389	PI 512370	Spain	7.5	9.0	7.7	9.0	4.0	-	9.0	8.0
390	PI 512390	Spain	7.5	9.0	7.8	9.0	6.0	-	9.0	6.0
391	PI 169286	Turkey	7.5	9.0	7.8	9.0	3.0	9.0	-	9.0
392	PI 482270	Zimbabwe	7.5	9.0	7.8	7.0	5.0	9.0	-	9.0
393	PI 179236	Turkey	7.5	9.0	7.8	-	3.0	9.0	9.0	9.0
394	PI 490385	Mali	7.5	9.0	7.8	-	6.0	-	-	9.0
395	PI 357691	Yugoslavia	7.5	9.0	7.9	9.0	4.0	9.0	-	8.0
396	PI 229806	Japan	7.5	9.0	7.9	9.0	3.0	9.0	-	9.0
397	PI 357676	Yugoslavia	7.5	9.0	7.9	-	4.0	9.0	9.0	8.0
398	PI 176907	Turkey	7.5	9.0	8.0	9.0	6.0	-	-	-
399	PI 278041	Turkey	7.5	9.0	8.2	9.0	-	3.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
400	PI 378617	Zaire	7.6	8.2	7.1	4.0	7.0	9.0	9.0	9.0
401	PI 438675	Mexico	7.6	8.2	7.2	5.0	6.0	9.0	9.0	9.0
402	Grif 1733	China	7.6	8.2	7.3	9.0	7.0	9.0	9.0	4.0
403	PI 505595	Zambia	7.6	8.4	7.4	9.0	3.0	9.0	9.0	8.0
404	PI 500327	Zambia	7.6	8.8	7.9	4.0	7.0	9.0	9.0	9.0
405	PI 500344	Zambia	7.6	9.0	7.3	9.0	6.0	9.0	9.0	5.0
406	PI 500318	Zambia	7.6	9.0	7.3	8.0	4.0	9.0	9.0	8.0
407	PI 482263	Zimbabwe	7.6	9.0	7.3	8.0	3.0	9.0	9.0	9.0
408	PI 246029	Chile	7.6	9.0	7.3	9.0	5.0	9.0	9.0	6.0
409	PI 534597	Syria	7.6	9.0	7.4	9.0	4.0	9.0	9.0	7.0
410	PI 381739	India	7.6	9.0	7.5	9.0	3.0	9.0	9.0	8.0
411	PI 512340	Spain	7.6	9.0	7.5	9.0	8.0	3.0	9.0	9.0
412	PI 482271	Zimbabwe	7.6	9.0	7.5	8.0	4.0	9.0	9.0	8.0
413	PI 270306	Philippines	7.6	9.0	7.6	9.0	3.0	9.0	9.0	8.0
414	PI 344298	Turkey	7.6	9.0	7.6	9.0	5.0	9.0	9.0	6.0
415	PI 482294	Zimbabwe	7.6	9.0	7.6	8.0	4.0	9.0	9.0	8.0
416	PI 167059	Turkey	7.6	9.0	7.6	8.0	9.0	3.0	9.0	9.0
417	PI 482344	Zimbabwe	7.6	9.0	7.6	7.0	6.0	9.0	9.0	7.0
418	PI 482260	Zimbabwe	7.6	9.0	7.7	7.0	6.0	9.0	9.0	7.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
419	PI 482376	Zimbabwe	7.6	9.0	7.7	8.0	4.0	9.0	9.0	8.0
420	PI 500310	Zambia	7.6	9.0	7.7	8.0	8.0	5.0	9.0	8.0
421	PI 379250	Yugoslavia	7.6	9.0	7.7	9.0	3.0	9.0	9.0	8.0
422	PI 532810	China	7.6	9.0	7.7	9.0	4.0	9.0	9.0	7.0
423	PI 487476	Israel	7.6	9.0	7.8	8.0	4.0	9.0	9.0	8.0
424	PI 482340	Zimbabwe	7.6	9.0	7.8	9.0	3.0	9.0	9.0	8.0
425	PI 169266	Turkey	7.6	9.0	7.8	8.0	4.0	9.0	9.0	8.0
426	PI 169236	Turkey	7.6	9.0	7.8	9.0	3.0	9.0	9.0	8.0
427	PI 525089	Egypt	7.6	9.0	7.8	8.0	4.0	9.0	9.0	8.0
428	PI 482375	Zimbabwe	7.6	9.0	7.9	9.0	5.0	9.0	9.0	6.0
429	PI 255139	S. Africa	7.6	9.0	7.9	9.0	3.0	9.0	9.0	8.0
430	PI 105445	Turkey	7.6	9.0	7.9	9.0	5.0	9.0	9.0	6.0
431	PI 278032	Turkey	7.6	9.0	7.9	9.0	8.0	4.0	9.0	8.0
432	PI 171584	Turkey	7.6	9.0	8.0	9.0	3.0	9.0	9.0	8.0
433	PI 169278	Turkey	7.6	9.0	8.0	9.0	3.0	9.0	9.0	8.0
434	PI 357696	Yugoslavia	7.6	9.0	8.0	9.0	4.0	9.0	9.0	7.0
435	PI 169280	Turkey	7.6	9.0	8.0	9.0	3.0	9.0	9.0	8.0
436	PI 169282	Turkey	7.6	9.0	8.1	9.0	9.0	3.0	9.0	8.0
437	PI 357746	Yugoslavia	7.7	8.0	7.2	-	-	9.0	9.0	5.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
438	PI 212208	Greece	7.7	9.0	7.4	-	5.0	9.0	9.0	-
439	PI 370015	India	7.7	9.0	7.5	-	6.0	-	9.0	8.0
440	PI 210017	India	7.7	9.0	7.6	-	-	9.0	6.0	8.0
441	PI 271988	Somalia	7.7	9.0	7.6	-	5.0	-	9.0	9.0
442	PI 248178	Zaire	7.7	9.0	7.7	9.0	5.0	-	9.0	-
443	PI 482283	Zimbabwe	7.7	9.0	7.7	-	6.0	9.0	-	8.0
444	PI 357753	Yugoslavia	7.7	9.0	7.8	-	-	9.0	9.0	5.0
445	PI 278016	Turkey	7.7	9.0	7.8	-	-	9.0	9.0	5.0
446	PI 556994	USA	7.7	9.0	7.8	-	5.0	9.0	9.0	-
447	PI 357657	Yugoslavia	7.7	9.0	7.9	-	-	5.0	9.0	9.0
448	PI 512354	Spain	7.7	9.0	7.9	9.0	5.0	-	9.0	-
449	PI 176916	Turkey	7.7	9.0	8.2	-	5.0	9.0	9.0	-
450	PI 505604	Zambia	7.8	8.0	7.6	5.0	8.0	9.0	-	9.0
451	PI 512350	Spain	7.8	9.0	7.4	-	4.0	9.0	9.0	9.0
452	PI 512396	Spain	7.8	9.0	7.5	9.0	4.0	9.0	9.0	-
453	PI 500306	Zambia	7.8	9.0	7.5	9.0	-	9.0	9.0	4.0
454	PI 177327	Turkey	7.8	9.0	7.5	9.0	4.0	9.0	9.0	-
455	PI 512371	Spain	7.8	9.0	7.6	9.0	4.0	-	9.0	9.0
456	PI 512356	Spain	7.8	9.0	7.6	-	4.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
457	PI 175665	Turkey	7.8	9.0	7.6	-	4.0	9.0	9.0	9.0
458	PI 357744	Yugoslavia	7.8	9.0	7.6	-	4.0	9.0	9.0	9.0
459	PI 378611	Zaire	7.8	9.0	7.6	8.0	5.0	9.0	9.0	-
460	PI 512401	Spain	7.8	9.0	7.6	8.0	6.0	9.0	-	8.0
461	PI 368512	Yugoslavia	7.8	9.0	7.7	9.0	9.0	-	9.0	4.0
462	PI 490386	Mali	7.8	9.0	7.8	9.0	4.0	-	9.0	9.0
463	PI 525100	Italy	7.8	9.0	7.8	9.0	4.0	9.0	9.0	-
464	PI 278033	Turkey	7.8	9.0	7.8	9.0	-	9.0	9.0	4.0
465	PI 174107	Turkey	7.8	9.0	7.8	-	4.0	9.0	9.0	9.0
466	PI 379238	Yugoslavia	7.8	9.0	7.8	-	5.0	9.0	9.0	8.0
467	PI 512353	Spain	7.8	9.0	7.8	-	5.0	9.0	9.0	8.0
468	PI 535947	Cameroon	7.8	9.0	7.8	9.0	4.0	9.0	9.0	-
469	PI 219907	Afghanistan	7.8	9.0	7.8	9.0	4.0	-	9.0	9.0
470	PI 512341	Spain	7.8	9.0	7.8	-	9.0	4.0	9.0	9.0
471	PI 368525	Yugoslavia	7.8	9.0	7.8	9.0	4.0	-	9.0	9.0
472	PI 379240	Yugoslavia	7.8	9.0	7.9	9.0	4.0	9.0	-	9.0
473	PI 172793	Turkey	7.8	9.0	7.9	9.0	9.0	4.0	9.0	-
474	PI 179241	Iraq	7.8	9.0	7.9	-	4.0	9.0	9.0	9.0
475	PI 271778	South Africa	7.8	9.0	7.9	8.0	5.0	9.0	9.0	-

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
476	PI 169265	Turkey	7.8	9.0	7.9	9.0	4.0	-	9.0	9.0
477	PI 169281	Turkey	7.8	9.0	7.9	9.0	4.0	9.0	-	9.0
478	PI 512378	Spain	7.8	9.0	7.9	9.0	4.0	-	9.0	9.0
479	PI 426625	Pakistan	7.8	9.0	7.9	-	4.0	9.0	9.0	9.0
480	PI 490383	Mali	7.8	9.0	7.9	9.0	4.0	-	9.0	9.0
481	PI 177330	Syria	7.8	9.0	7.9	8.0	5.0	9.0	9.0	-
482	PI 270140	India	7.8	9.0	8.0	9.0	5.0	-	9.0	8.0
483	PI 500307	Zambia	7.8	9.0	8.0	9.0	5.0	9.0	-	8.0
484	PI 169267	Turkey	7.8	9.0	8.0	9.0	6.0	9.0	-	7.0
485	PI 172799	Turkey	7.8	9.0	8.0	9.0	4.0	9.0	9.0	-
486	PI 182180	Turkey	7.8	9.0	8.0	-	4.0	9.0	9.0	9.0
487	Grif 1732	China	7.8	9.0	8.0	9.0	5.0	-	9.0	8.0
488	PI 172792	Turkey	7.8	9.0	8.0	9.0	5.0	-	9.0	8.0
489	PI 167219	Turkey	7.8	9.0	8.0	9.0	4.0	-	9.0	9.0
490	PI 229748	Iran	7.8	9.0	8.0	9.0	4.0	-	9.0	9.0
491	PI 179243	Turkey	7.8	9.0	8.0	9.0	4.0	9.0	9.0	-
492	PI 176917	Turkey	7.8	9.0	8.0	9.0	4.0	-	9.0	9.0
493	PI 169269	Turkey	7.8	9.0	8.0	9.0	4.0	-	9.0	9.0
494	PI 165451	Mexico	7.8	9.0	8.0	9.0	4.0	-	9.0	9.0

(continued next page)

Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
495	PI 278024	Turkey	7.8	9.0	8.0	9.0	4.0	9.0	9.0	-
496	PI 357673	Yugoslavia	7.8	9.0	8.0	9.0	4.0	9.0	9.0	-
497	PI 357731	Yugoslavia	7.8	9.0	8.1	9.0	4.0	9.0	-	9.0
498	PI 169257	Turkey	7.8	9.0	8.1	9.0	4.0	9.0	9.0	-
499	PI 164570	India	7.8	9.0	8.1	8.0	5.0	9.0	9.0	-
500	PI 512344	Spain	7.8	9.0	8.2	9.0	4.0	-	9.0	9.0
501	PI 277980	Turkey	7.8	9.0	8.2	9.0	4.0	9.0	-	9.0
502	PI 169237	Turkey	7.8	9.0	8.2	9.0	4.0	9.0	9.0	-
503	PI 307749	Philippines	7.8	9.0	8.2	9.0	4.0	9.0	9.0	-
504	PI 306366	Taiwan	7.8	9.0	8.2	9.0	-	9.0	9.0	4.0
505	PI 368493	Yugoslavia	7.8	9.0	8.3	9.0	4.0	-	9.0	9.0
506	PI 181935	Syria	7.8	8.0	7.2	9.0	4.0	9.0	9.0	8.0
507	PI 173888	India	7.8	8.0	7.4	9.0	4.0	9.0	9.0	8.0
508	PI 560901	China	7.8	8.6	7.3	7.0	5.0	9.0	9.0	9.0
509	PI 500321	Zambia	7.8	9.0	7.2	9.0	4.0	9.0	9.0	8.0
510	PI 500337	Zambia	7.8	9.0	7.3	9.0	4.0	9.0	9.0	8.0
511	PI 306365	Taiwan	7.8	9.0	7.3	9.0	3.0	9.0	9.0	9.0
512	PI 172789	Turkey	7.8	9.0	7.4	9.0	3.0	9.0	9.0	9.0
513	PI 482349	Zimbabwe	7.8	9.0	7.4	8.0	4.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
514	PI 368507	Yugoslavia	7.8	9.0	7.4	9.0	3.0	9.0	9.0	9.0
515	PI 537270	Pakistan	7.8	9.0	7.5	9.0	3.0	9.0	9.0	9.0
516	PI 189317	Zaire	7.8	9.0	7.5	8.0	9.0	9.0	9.0	4.0
517	PI 271750	Ghana	7.8	9.0	7.5	9.0	4.0	9.0	9.0	8.0
518	PI 388021	India	7.8	9.0	7.5	9.0	4.0	9.0	9.0	8.0
519	PI 526236	Zimbabwe	7.8	9.0	7.5	9.0	6.0	9.0	9.0	6.0
520	PI 482287	Zimbabwe	7.8	9.0	7.6	9.0	3.0	9.0	9.0	9.0
521	PI 505584	Zambia	7.8	9.0	7.6	8.0	5.0	9.0	9.0	8.0
522	PI 169251	Turkey	7.8	9.0	7.6	9.0	4.0	9.0	9.0	8.0
523	PI 500336	Zambia	7.8	9.0	7.6	8.0	5.0	9.0	9.0	8.0
524	PI 368511	Yugoslavia	7.8	9.0	7.6	9.0	3.0	9.0	9.0	9.0
525	PI 180276	India	7.8	9.0	7.6	9.0	4.0	9.0	9.0	8.0
526	PI 169295	Turkey	7.8	9.0	7.6	9.0	4.0	9.0	9.0	8.0
527	PI 534531	Syria	7.8	9.0	7.6	9.0	4.0	9.0	9.0	8.0
528	PI 171579	Turkey	7.8	9.0	7.6	9.0	7.0	9.0	9.0	5.0
529	PI 176487	Turkey	7.8	9.0	7.7	9.0	4.0	9.0	9.0	8.0
530	PI 220779	Afghanistan	7.8	9.0	7.7	9.0	4.0	9.0	9.0	8.0
531	PI 183126	India	7.8	9.0	7.7	9.0	4.0	9.0	9.0	8.0
532	PI 176488	Turkey	7.8	9.0	7.7	9.0	4.0	9.0	9.0	8.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
533	PI 482266	Zimbabwe	7.8	9.0	7.7	9.0	4.0	9.0	9.0	8.0
534	PI 482262	Zimbabwe	7.8	9.0	7.7	8.0	5.0	9.0	9.0	8.0
535	PI 512382	Spain	7.8	9.0	7.7	9.0	4.0	9.0	9.0	8.0
536	PI 217939	Pakistan	7.8	9.0	7.7	8.0	4.0	9.0	9.0	9.0
537	PI 537273	Pakistan	7.8	9.0	7.7	9.0	4.0	9.0	9.0	8.0
538	PI 505589	Zambia	7.8	9.0	7.7	9.0	4.0	9.0	9.0	8.0
539	PI 223764	Afghanistan	7.8	9.0	7.7	9.0	3.0	9.0	9.0	9.0
540	PI 179879	India	7.8	9.0	7.7	9.0	4.0	9.0	9.0	8.0
541	PI 482293	Zimbabwe	7.8	9.0	7.7	7.0	5.0	9.0	9.0	9.0
542	PI 482290	Zimbabwe	7.8	9.0	7.7	9.0	4.0	9.0	9.0	8.0
543	PI 271777	S.Africa	7.8	9.0	7.7	7.0	6.0	9.0	9.0	8.0
544	PI 379232	Yugoslavia	7.8	9.0	7.8	9.0	3.0	9.0	9.0	9.0
545	PI 549159	Yugoslavia	7.8	9.0	7.8	9.0	4.0	9.0	9.0	8.0
546	PI 525087	Egypt	7.8	9.0	7.8	8.0	5.0	9.0	9.0	8.0
547	PI 482310	Zimbabwe	7.8	9.0	7.8	6.0	6.0	9.0	9.0	9.0
548	PI 357741	Yugoslavia	7.8	9.0	7.8	9.0	3.0	9.0	9.0	9.0
549	PI 482374	Zimbabwe	7.8	9.0	7.8	8.0	5.0	9.0	9.0	8.0
550	PI 379234	Yugoslavia	7.8	9.0	7.8	9.0	4.0	9.0	9.0	8.0
551	PI 512388	Spain	7.8	9.0	7.8	8.0	5.0	9.0	9.0	8.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
552	PI 534589	Syria	7.8	9.0	7.8	9.0	4.0	9.0	9.0	8.0
553	PI 534534	Syria	7.8	9.0	7.8	9.0	3.0	9.0	9.0	9.0
554	PI 381705	India	7.8	9.0	7.8	9.0	3.0	9.0	9.0	9.0
555	PI 470246	Indonesia	7.8	9.0	7.8	9.0	4.0	9.0	9.0	8.0
556	PI 505594	Zambia	7.8	9.0	7.8	9.0	4.0	9.0	9.0	8.0
557	PI 176494	Turkey	7.8	9.0	7.8	9.0	9.0	3.0	9.0	9.0
558	Grif 5596	India	7.8	9.0	7.8	9.0	3.0	9.0	9.0	9.0
559	PI 512398	Spain	7.8	9.0	7.8	9.0	3.0	9.0	9.0	9.0
560	PI 435085	China	7.8	9.0	7.8	9.0	4.0	9.0	9.0	8.0
561	PI 482345	Zimbabwe	7.8	9.0	7.8	9.0	4.0	9.0	9.0	8.0
562	PI 175102	India	7.8	9.0	7.8	9.0	4.0	9.0	9.0	8.0
563	PI 181936	Syria	7.8	9.0	7.8	9.0	5.0	9.0	9.0	7.0
564	PI 561138	USA	7.8	9.0	7.8	9.0	4.0	9.0	9.0	8.0
565	PI 494820	Zambia	7.8	9.0	7.8	8.0	5.0	9.0	9.0	8.0
566	PI 177325	Turkey	7.8	9.0	7.9	9.0	3.0	9.0	9.0	9.0
567	PI 279460	Japan	7.8	9.0	7.9	9.0	3.0	9.0	9.0	9.0
568	PI 534587	Syria	7.8	9.0	7.9	9.0	4.0	9.0	9.0	8.0
569	PI 368509	Yugoslavia	7.8	9.0	7.9	9.0	3.0	9.0	9.0	9.0
570	PI 381723	India	7.8	9.0	7.9	9.0	3.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
571	PI 476325	Ukraine	7.8	9.0	7.9	9.0	4.0	9.0	9.0	8.0
572	PI 470247	Indonesia	7.8	9.0	7.9	9.0	4.0	9.0	9.0	8.0
573	PI 254740	Senegal	7.8	9.0	7.9	9.0	5.0	9.0	9.0	7.0
574	PI 595218	USA	7.8	9.0	7.9	9.0	4.0	9.0	9.0	8.0
575	PI 222776	Iran	7.8	9.0	7.9	9.0	3.0	9.0	9.0	9.0
576	PI 277975	Turkey	7.8	9.0	7.9	9.0	4.0	9.0	9.0	8.0
577	PI 379235	Yugoslavia	7.8	9.0	7.9	9.0	4.0	9.0	9.0	8.0
578	PI 171580	Turkey	7.8	9.0	7.9	9.0	7.0	5.0	9.0	9.0
579	PI 172801	Turkey	7.8	9.0	7.9	9.0	3.0	9.0	9.0	9.0
580	PI 476329	Soviet Union	7.8	9.0	7.9	9.0	9.0	5.0	9.0	7.0
581	PI 277974	Turkey	7.8	9.0	7.9	9.0	3.0	9.0	9.0	9.0
582	PI 379252	Yugoslavia	7.8	9.0	7.9	9.0	3.0	9.0	9.0	9.0
583	PI 512351	Spain	7.8	9.0	7.9	9.0	9.0	3.0	9.0	9.0
584	PI 379233	Yugoslavia	7.8	9.0	7.9	9.0	4.0	9.0	9.0	8.0
585	PI 464872	China	7.8	9.0	8.0	9.0	5.0	9.0	9.0	7.0
586	PI 512389	Spain	7.8	9.0	8.0	9.0	9.0	9.0	3.0	9.0
587	PI 381718	India	7.8	9.0	8.0	9.0	4.0	9.0	9.0	8.0
588	PI 508446	S.Korea	7.8	9.0	8.0	9.0	4.0	9.0	9.0	8.0
589	PI 357672	Yugoslavia	7.8	9.0	8.0	9.0	3.0	9.0	9.0	9.0

(continued next page)

Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
590	PI 176912	Turkey	7.8	9.0	8.0	9.0	9.0	3.0	9.0	9.0
591	PI 164998	Turkey	7.8	9.0	8.0	9.0	3.0	9.0	9.0	9.0
592	PI 179882	India	7.8	9.0	8.0	9.0	4.0	9.0	9.0	8.0
593	PI 172805	Turkey	7.8	9.0	8.0	9.0	5.0	9.0	9.0	7.0
594	PI 270547	Ghana	7.8	9.0	8.1	9.0	3.0	9.0	9.0	9.0
595	PI 226459	Iran	7.8	9.0	8.1	9.0	3.0	9.0	9.0	9.0
596	PI 357723	Yugoslavia	7.8	9.0	8.1	9.0	3.0	9.0	9.0	9.0
597	PI 438674	Mexico	7.8	9.0	8.1	9.0	3.0	9.0	9.0	9.0
598	PI 192937	China	7.8	9.0	8.1	9.0	3.0	9.0	9.0	9.0
599	PI 169246	Turkey	7.8	9.0	8.1	9.0	3.0	9.0	9.0	9.0
600	PI 506439	Moldova	7.8	9.0	8.1	9.0	4.0	9.0	9.0	8.0
601	PI 500334	Zambia	7.8	9.0	8.1	9.0	6.0	9.0	9.0	6.0
602	PI 296343	S.Africa	7.8	9.0	8.1	9.0	4.0	9.0	9.0	8.0
603	PI 381741	India	7.8	9.0	8.2	9.0	3.0	9.0	9.0	9.0
604	PI 537265	Pakistan	7.8	9.0	8.2	9.0	3.0	9.0	9.0	9.0
605	PI 178872	Turkey	7.8	9.0	8.2	8.0	5.0	9.0	9.0	8.0
606	PI 525090	Egypt	7.8	9.0	8.2	9.0	4.0	9.0	9.0	8.0
607	PI 175651	Turkey	7.8	9.0	8.2	9.0	3.0	9.0	9.0	9.0
608	PI 357721	Yugoslavia	7.8	9.0	8.3	9.0	3.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
609	PI 176492	Turkey	8.0	8.0	7.3	6.0	-	9.0	9.0	-
610	PI 270551	Ghana	8.0	8.3	6.9	7.0	8.0	9.0	-	-
611	PI 163205	India	8.0	8.3	7.7	6.0	-	9.0	-	9.0
612	PI 379237	Yugoslavia	8.0	8.4	7.6	6.0	7.0	9.0	9.0	9.0
613	PI 226460	Iran	8.0	8.4	7.7	9.0	9.0	4.0	9.0	9.0
614	PI 186975	Ghana	8.0	8.6	7.8	9.0	4.0	9.0	9.0	9.0
615	PI 381717	India	8.0	8.8	7.7	8.0	5.0	9.0	9.0	9.0
616	PI 277979	Turkey	8.0	9.0	6.5	-	-	-	-	8.0
617	PI 270562	S. Africa	8.0	9.0	7.0	-	8.0	-	-	-
618	PI 299563	S. Africa	8.0	9.0	7.4	9.0	5.0	9.0	9.0	8.0
619	PI 504519	Australia	8.0	9.0	7.4	9.0	7.0	-	-	-
620	PI 270143	India	8.0	9.0	7.4	-	5.0	9.0	9.0	9.0
621	PI 482378	Zimbabwe	8.0	9.0	7.5	8.0	5.0	9.0	9.0	9.0
622	PI 293766	Soviet Union	8.0	9.0	7.5	-	-	-	-	8.0
623	PI 482327	Zimbabwe	8.0	9.0	7.5	9.0	4.0	9.0	9.0	9.0
624	PI 169234	Turkey	8.0	9.0	7.6	9.0	4.0	9.0	9.0	9.0
625	PI 269676	Belize	8.0	9.0	7.6	9.0	4.0	9.0	9.0	9.0
626	PI 368501	Yugoslavia	8.0	9.0	7.6	9.0	5.0	9.0	9.0	8.0
627	PI 167045	Turkey	8.0	9.0	7.6	9.0	5.0	-	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
628	PI 482333	Zimbabwe	8.0	9.0	7.6	7.0	7.0	9.0	9.0	8.0
629	PI 525099	Italy	8.0	9.0	7.6	9.0	5.0	9.0	9.0	8.0
630	PI 482339	Zimbabwe	8.0	9.0	7.7	8.0	5.0	9.0	9.0	9.0
631	PI 525095	Egypt	8.0	9.0	7.7	9.0	4.0	9.0	9.0	9.0
632	PI 326515	Ghana	8.0	9.0	7.7	6.0	9.0	9.0	-	-
633	PI 193965	Ethiopia	8.0	9.0	7.7	9.0	4.0	9.0	9.0	9.0
634	PI 438671	Mexico	8.0	9.0	7.7	9.0	5.0	9.0	9.0	8.0
635	PI 357665	Yugoslavia	8.0	9.0	7.7	9.0	5.0	-	9.0	9.0
636	PI 512402	Spain	8.0	9.0	7.8	-	5.0	9.0	9.0	9.0
637	PI 211917	Iran	8.0	9.0	7.8	-	7.0	9.0	-	-
638	PI 271983	Somalia	8.0	9.0	7.8	9.0	4.0	9.0	9.0	9.0
639	PI 482284	Zimbabwe	8.0	9.0	7.8	9.0	5.0	9.0	9.0	8.0
640	PI 482329	Zimbabwe	8.0	9.0	7.8	6.0	7.0	9.0	9.0	9.0
641	PI 482328	Zimbabwe	8.0	9.0	7.8	5.0	9.0	9.0	9.0	8.0
642	PI 482253	Zimbabwe	8.0	9.0	7.8	9.0	4.0	9.0	9.0	9.0
643	PI 172790	Turkey	8.0	9.0	7.8	9.0	4.0	9.0	9.0	9.0
644	PI 271751	Ghana	8.0	9.0	7.8	9.0	4.0	9.0	9.0	9.0
645	Grif 12335	China	8.0	9.0	7.8	9.0	5.0	9.0	9.0	8.0
646	PI 240533	Iran	8.0	9.0	7.8	8.0	-	-	-	-

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
647	PI 162667	Argentina	8.0	9.0	7.8	9.0	5.0	9.0	9.0	8.0
648	PI 505586	Zambia	8.0	9.0	7.8	8.0	6.0	9.0	9.0	8.0
649	PI 500348	Zambia	8.0	9.0	7.8	9.0	5.0	9.0	-	9.0
650	Grif 12336	China	8.0	9.0	7.8	9.0	5.0	9.0	9.0	8.0
651	PI 482334	Zimbabwe	8.0	9.0	7.8	9.0	5.0	9.0	9.0	8.0
652	PI 500352	Zambia	8.0	9.0	7.8	7.0	8.0	-	9.0	8.0
653	PI 207472	Afghanistan	8.0	9.0	7.8	-	5.0	9.0	9.0	9.0
654	PI 537299	Uzbekistan	8.0	9.0	7.9	9.0	4.0	9.0	9.0	9.0
655	PI 200733	Guatemala	8.0	9.0	7.9	8.0	-	9.0	-	7.0
656	PI 381697	India	8.0	9.0	7.9	9.0	-	5.0	9.0	9.0
657	PI 175650	Turkey	8.0	9.0	7.9	9.0	4.0	9.0	9.0	9.0
658	PI 169256	Turkey	8.0	9.0	7.9	9.0	5.0	9.0	9.0	8.0
659	PI 229749	Iran	8.0	9.0	7.9	9.0	5.0	9.0	9.0	8.0
660	PI 500323	Zambia	8.0	9.0	7.9	9.0	5.0	9.0	9.0	8.0
661	PI 512368	Spain	8.0	9.0	7.9	9.0	4.0	9.0	9.0	9.0
662	PI 164539	India	8.0	9.0	7.9	9.0	4.0	9.0	9.0	9.0
663	PI 278054	Turkey	8.0	9.0	7.9	9.0	4.0	9.0	9.0	9.0
664	PI 370427	Yugoslavia	8.0	9.0	7.9	9.0	6.0	-	9.0	8.0
665	PI 508441	S.Korea	8.0	9.0	7.9	8.0	5.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
666	PI 254743	Senegal	8.0	9.0	7.9	9.0	4.0	9.0	9.0	9.0
667	PI 278051	Turkey	8.0	9.0	7.9	9.0	4.0	9.0	9.0	9.0
668	PI 500324	Zambia	8.0	9.0	7.9	9.0	5.0	9.0	9.0	8.0
669	PI 357717	Yugoslavia	8.0	9.0	7.9	9.0	9.0	9.0	9.0	4.0
670	PI 534598	Syria	8.0	9.0	7.9	9.0	4.0	9.0	9.0	9.0
671	PI 494529	Nigeria	8.0	9.0	7.9	9.0	-	9.0	9.0	5.0
672	PI 169285	Turkey	8.0	9.0	7.9	9.0	4.0	9.0	9.0	9.0
673	PI 357724	Yugoslavia	8.0	9.0	7.9	9.0	5.0	9.0	-	9.0
674	PI 227203	Japan	8.0	9.0	7.9	9.0	5.0	9.0	-	9.0
675	PI 181742	Lebanon	8.0	9.0	7.9	9.0	4.0	9.0	9.0	9.0
676	PI 174101	Turkey	8.0	9.0	7.9	9.0	4.0	9.0	9.0	9.0
677	PI 169235	Turkey	8.0	9.0	7.9	9.0	4.0	9.0	9.0	9.0
678	PI 174106	Turkey	8.0	9.0	7.9	9.0	4.0	9.0	9.0	9.0
679	PI 370018	India	8.0	9.0	7.9	9.0	4.0	9.0	9.0	9.0
680	PI 482380	Zimbabwe	8.0	9.0	7.9	9.0	5.0	9.0	9.0	8.0
681	PI 482277	Zimbabwe	8.0	9.0	7.9	8.0	5.0	9.0	9.0	9.0
682	PI 270307	Philippines	8.0	9.0	7.9	9.0	4.0	9.0	9.0	9.0
683	PI 512373	Spain	8.0	9.0	7.9	9.0	5.0	9.0	9.0	-
684	PI 249559	Thailand	8.0	9.0	7.9	9.0	4.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
685	PI 357733	Yugoslavia	8.0	9.0	8.0	9.0	5.0	9.0	-	9.0
686	PI 165448	Mexico	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
687	PI 512348	Spain	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
688	PI 169239	Turkey	8.0	9.0	8.0	9.0	5.0	9.0	9.0	8.0
689	PI 502316	Uzbekistan	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
690	PI 476327	Uzbekistan	8.0	9.0	8.0	9.0	5.0	9.0	9.0	8.0
691	PI 277984	Turkey	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
692	PI 381715	India	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
693	PI 167125	Turkey	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
694	PI 227204	Japan	8.0	9.0	8.0	9.0	5.0	9.0	9.0	8.0
695	PI 500311	Zambia	8.0	9.0	8.0	9.0	5.0	9.0	9.0	-
696	PI 379247	Yugoslavia	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
697	PI 512352	Spain	8.0	9.0	8.0	9.0	-	9.0	9.0	5.0
698	PI 269677	Belize	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
699	PI 442826	Brazil	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
700	PI 470249	Indonesia	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
701	PI 169300	Turkey	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
702	PI 500312	Zambia	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
703	PI 500353	Zambia	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
704	PI 271984	Somalia	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
705	PI 543212	Bolivia	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
706	PI 482252	Zimbabwe	8.0	9.0	8.0	8.0	6.0	9.0	9.0	8.0
707	PI 357709	Yugoslavia	8.0	9.0	8.0	9.0	5.0	9.0	-	9.0
708	PI 357689	Yugoslavia	8.0	9.0	8.0	9.0	5.0	9.0	9.0	8.0
709	PI 476324	Soviet Union	8.0	9.0	8.0	9.0	5.0	9.0	9.0	8.0
710	PI 270549	Ghana	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
711	PI 357667	Yugoslavia	8.0	9.0	8.0	7.0	-	9.0	-	-
712	PI 357684	Yugoslavia	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
713	PI 379227	Yugoslavia	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
714	PI 171586	Turkey	8.0	9.0	8.0	9.0	9.0	4.0	9.0	9.0
715	PI 167026	Turkey	8.0	9.0	8.0	9.0	6.0	-	9.0	8.0
716	PI 169250	Turkey	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
717	PI 512392	Spain	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
718	PI 512403	Spain	8.0	9.0	8.0	9.0	4.0	9.0	9.0	9.0
719	PI 378615	Zaire	8.0	9.0	8.0	9.0	6.0	-	9.0	8.0
720	PI 179886	India	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0
721	PI 180277	India	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0
722	PI 180426	India	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
723	PI 505592	Zambia	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0
724	PI 179242	Iraq	8.0	9.0	8.1	8.0	6.0	-	9.0	9.0
725	PI 482337	Zimbabwe	8.0	9.0	8.1	9.0	5.0	9.0	9.0	8.0
726	PI 275631	India	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0
727	PI 179884	India	8.0	9.0	8.1	-	5.0	9.0	9.0	9.0
728	PI 176495	Turkey	8.0	9.0	8.1	9.0	-	9.0	9.0	5.0
729	PI 368529	Yugoslavia	8.0	9.0	8.1	9.0	5.0	-	9.0	9.0
730	PI 299379	S.Africa	8.0	9.0	8.1	9.0	5.0	9.0	9.0	8.0
731	PI 169291	Turkey	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0
732	Grif 5597	India	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0
733	PI 273479	Ethiopia	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0
734	PI 536457	Maldives	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0
735	PI 179878	India	8.0	9.0	8.1	9.0	6.0	9.0	9.0	7.0
736	PI 357720	Yugoslavia	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0
737	PI 381714	India	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0
738	PI 169276	Turkey	8.0	9.0	8.1	9.0	5.0	9.0	9.0	8.0
739	PI 534594	Syria	8.0	9.0	8.1	9.0	5.0	9.0	9.0	-
740	PI 189225	Zaire	8.0	9.0	8.1	7.0	6.0	9.0	9.0	9.0
741	PI 507858	Hungary	8.0	9.0	8.1	8.0	8.0	9.0	9.0	6.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
742	PI 475746	Paraguay	8.0	9.0	8.1	9.0	5.0	9.0	9.0	8.0
743	PI 178876	Turkey	8.0	9.0	8.1	9.0	6.0	9.0	-	8.0
744	PI 174108	Turkey	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0
745	PI 379226	Yugoslavia	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0
746	PI 169240	Turkey	8.0	9.0	8.1	-	5.0	9.0	9.0	9.0
747	PI 277973	Turkey	8.0	9.0	8.1	9.0	-	9.0	9.0	5.0
748	PI 368527	Yugoslavia	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0
749	PI 381699	India	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0
750	PI 559995	Nigeria	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0
751	PI 176486	Turkey	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0
752	PI 271985	Somalia	8.0	9.0	8.1	9.0	4.0	9.0	9.0	9.0
753	PI 204689	Turkey	8.0	9.0	8.1	8.0	5.0	9.0	9.0	9.0
754	PI 176919	Turkey	8.0	9.0	8.1	9.0	9.0	4.0	9.0	9.0
755	PI 507868	Hungary	8.0	9.0	8.2	9.0	4.0	9.0	9.0	9.0
756	PI 357704	Yugoslavia	8.0	9.0	8.2	9.0	5.0	-	9.0	9.0
757	PI 180278	India	8.0	9.0	8.2	9.0	5.0	9.0	9.0	8.0
758	PI 182179	Turkey	8.0	9.0	8.2	9.0	5.0	9.0	9.0	8.0
759	PI 169275	Turkey	8.0	9.0	8.2	-	-	9.0	9.0	6.0
760	PI 368528	Yugoslavia	8.0	9.0	8.2	9.0	4.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
761	PI 357738	Yugoslavia	8.0	9.0	8.2	9.0	7.0	-	-	-
762	PI 381708	India	8.0	9.0	8.2	-	5.0	9.0	9.0	9.0
763	PI 435991	China	8.0	9.0	8.2	8.0	5.0	9.0	9.0	9.0
764	PI 542617	Algeria	8.0	9.0	8.2	9.0	5.0	9.0	9.0	8.0
765	PI 169293	Turkey	8.0	9.0	8.2	9.0	4.0	9.0	9.0	9.0
766	PI 214044	India	8.0	9.0	8.2	9.0	4.0	9.0	9.0	9.0
767	PI 219691	Pakistan	8.0	9.0	8.2	9.0	4.0	9.0	9.0	9.0
768	PI 357719	Yugoslavia	8.0	9.0	8.2	9.0	4.0	9.0	9.0	9.0
769	PI 379255	Yugoslavia	8.0	9.0	8.2	9.0	4.0	9.0	9.0	9.0
770	PI 169273	Turkey	8.0	9.0	8.2	9.0	4.0	9.0	9.0	9.0
771	PI 164708	India	8.0	9.0	8.2	9.0	5.0	9.0	9.0	8.0
772	PI 500335	Zambia	8.0	9.0	8.2	9.0	-	9.0	5.0	9.0
773	PI 278031	Turkey	8.0	9.0	8.2	9.0	5.0	9.0	-	9.0
774	PI 490375	Mali	8.0	9.0	8.2	-	6.0	9.0	-	9.0
775	PI 357656	Yugoslavia	8.0	9.0	8.2	9.0	4.0	9.0	9.0	9.0
776	PI 249008	Nigeria	8.0	9.0	8.2	9.0	-	5.0	9.0	9.0
777	PI 379224	Yugoslavia	8.0	9.0	8.2	9.0	5.0	9.0	9.0	-
778	PI 295845	South Africa	8.0	9.0	8.3	-	-	-	9.0	7.0
779	PI 271775	South Africa	8.0	9.0	8.3	9.0	5.0	-	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
780	PI 188808	Philippines	8.0	9.0	8.3	9.0	5.0	9.0	9.0	-
781	Grif 5598	India	8.0	9.0	8.3	9.0	4.0	9.0	9.0	9.0
782	PI 536463	Maldives	8.0	9.0	8.3	-	5.0	9.0	9.0	9.0
783	PI 458738	Paraguay	8.0	9.0	8.3	9.0	4.0	9.0	9.0	9.0
784	PI 222713	Iran	8.0	9.0	8.4	9.0	4.0	9.0	9.0	9.0
785	PI 270141	India	8.2	8.6	8.2	5.0	9.0	9.0	9.0	9.0
786	PI 505585	Zambia	8.2	9.0	7.6	9.0	5.0	9.0	9.0	9.0
787	PI 482247	Zimbabwe	8.2	9.0	7.6	8.0	7.0	9.0	9.0	8.0
788	PI 482324	Zimbabwe	8.2	9.0	7.7	8.0	6.0	9.0	9.0	9.0
789	PI 181937	Syria	8.2	9.0	7.8	9.0	5.0	9.0	9.0	9.0
790	PI 532624	Zimbabwe	8.2	9.0	7.8	8.0	7.0	9.0	9.0	8.0
791	PI 189316	Nigeria	8.2	9.0	7.8	8.0	6.0	9.0	9.0	9.0
792	PI 532814	China	8.2	9.0	7.8	9.0	7.0	9.0	9.0	7.0
793	PI 490384	Mali	8.2	9.0	7.9	9.0	5.0	9.0	9.0	9.0
794	PI 164992	Turkey	8.2	9.0	7.9	9.0	5.0	9.0	9.0	9.0
795	PI 357661	Yugoslavia	8.2	9.0	7.9	9.0	9.0	9.0	9.0	5.0
796	PI 537471	Spain	8.2	9.0	7.9	9.0	6.0	9.0	9.0	8.0
797	PI 368502	Yugoslavia	8.2	9.0	7.9	7.0	7.0	9.0	9.0	9.0
798	PI 357688	Yugoslavia	8.2	9.0	7.9	9.0	5.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
799	PI 512395	Spain	8.2	9.0	7.9	5.0	9.0	9.0	9.0	9.0
800	PI 470248	Indonesia	8.2	9.0	7.9	9.0	6.0	9.0	9.0	8.0
801	PI 173669	Turkey	8.2	9.0	7.9	9.0	6.0	9.0	9.0	8.0
802	PI 378616	Zaire	8.2	9.0	7.9	9.0	5.0	9.0	9.0	9.0
803	PI 179883	India	8.2	9.0	7.9	8.0	6.0	9.0	9.0	9.0
804	PI 482300	Zimbabwe	8.2	9.0	8.0	9.0	6.0	9.0	9.0	8.0
805	PI 482360	Zimbabwe	8.2	9.0	8.0	9.0	5.0	9.0	9.0	9.0
806	PI 500345	Zambia	8.2	9.0	8.0	9.0	5.0	9.0	9.0	9.0
807	PI 525094	Egypt	8.2	9.0	8.0	9.0	5.0	9.0	9.0	9.0
808	PI 494819	Zambia	8.2	9.0	8.0	9.0	5.0	9.0	9.0	9.0
809	PI 164977	Turkey	8.2	9.0	8.0	9.0	5.0	9.0	9.0	9.0
810	PI 357713	Yugoslavia	8.2	9.0	8.0	9.0	5.0	9.0	9.0	9.0
811	PI 512400	Spain	8.2	9.0	8.0	8.0	6.0	9.0	9.0	9.0
812	PI 532659	S. Africa	8.2	9.0	8.0	9.0	5.0	9.0	9.0	9.0
813	PI 176491	Turkey	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0
814	PI 164709	India	8.2	9.0	8.1	9.0	8.0	9.0	9.0	6.0
815	PI 512363	Spain	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0
816	PI 172804	Turkey	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0
817	PI 178871	Turkey	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
818	PI 526238	Zimbabwe	8.2	9.0	8.1	8.0	6.0	9.0	9.0	9.0
819	PI 169254	Turkey	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0
820	PI 183022	India	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0
821	PI 512360	Spain	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0
822	PI 482302	Zimbabwe	8.2	9.0	8.1	8.0	6.0	9.0	9.0	9.0
823	PI 534596	Syria	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0
824	PI 482288	Zimbabwe	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0
825	PI 277996	Turkey	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0
826	PI 536458	Maldives	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0
827	PI 507866	Hungary	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0
828	PI 512365	Spain	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0
829	PI 164634	India	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0
830	PI 512828	Spain	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0
831	PI 368522	Yugoslavia	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0
832	PI 368523	Yugoslavia	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0
833	PI 270309	Philippines	8.2	9.0	8.1	9.0	6.0	9.0	9.0	8.0
834	PI 512387	Spain	8.2	9.0	8.1	9.0	7.0	9.0	9.0	7.0
835	PI 482301	Zimbabwe	8.2	9.0	8.1	9.0	6.0	9.0	9.0	8.0
836	PI 253174	Yugoslavia	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
837	PI 181740	Lebanon	8.2	9.0	8.1	9.0	5.0	9.0	9.0	9.0
838	PI 163572	Guatemala	8.2	9.0	8.2	9.0	5.0	9.0	9.0	9.0
839	PI 534583	Syria	8.2	9.0	8.2	9.0	6.0	9.0	9.0	8.0
840	PI 357714	Yugoslavia	8.2	9.0	8.2	9.0	5.0	9.0	9.0	9.0
841	PI 536451	Maldives	8.2	9.0	8.2	9.0	5.0	9.0	9.0	9.0
842	PI 182935	India	8.2	9.0	8.2	9.0	5.0	9.0	9.0	9.0
843	PI 254735	Senegal	8.2	9.0	8.2	9.0	5.0	9.0	9.0	9.0
844	PI 269680	Belize	8.2	9.0	8.2	9.0	5.0	9.0	9.0	9.0
845	PI 269681	Belize	8.2	9.0	8.2	9.0	5.0	9.0	9.0	9.0
846	PI 307750	Philippines	8.2	9.0	8.2	9.0	5.0	9.0	9.0	9.0
847	PI 430615	China	8.2	9.0	8.2	8.0	6.0	9.0	9.0	9.0
848	PI 200732	El Salvador	8.2	9.0	8.2	8.0	6.0	9.0	9.0	9.0
849	PI 512366	Spain	8.2	9.0	8.2	8.0	6.0	9.0	9.0	9.0
850	PI 276658	Soviet Union	8.2	9.0	8.2	9.0	5.0	9.0	9.0	9.0
851	PI 536464	Maldives	8.2	9.0	8.2	9.0	5.0	9.0	9.0	9.0
852	PI 164655	India	8.2	9.0	8.2	9.0	5.0	9.0	9.0	9.0
853	PI 163574	Guatemala	8.2	9.0	8.3	9.0	5.0	9.0	9.0	9.0
854	PI 370423	Yugoslavia	8.2	9.0	8.3	9.0	5.0	9.0	9.0	9.0
856	PI 270545	Sudan	8.2	9.0	8.3	9.0	5.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
857	PI 270550	Ghana	8.2	9.0	8.3	9.0	5.0	9.0	9.0	9.0
858	PI 357659	Yugoslavia	8.2	9.0	8.3	9.0	5.0	9.0	9.0	9.0
859	PI 512405	Spain	8.2	9.0	8.3	9.0	5.0	9.0	9.0	9.0
860	PI 536460	Maldives	8.2	9.0	8.3	9.0	5.0	9.0	9.0	9.0
861	PI 180427	India	8.2	9.0	8.3	9.0	5.0	9.0	9.0	9.0
862	PI 500317	Zambia	8.2	9.0	8.3	9.0	5.0	9.0	9.0	9.0
863	PI 512339	Spain	8.2	9.0	8.3	9.0	5.0	9.0	9.0	9.0
864	PI 175652	Turkey	8.2	9.0	8.3	9.0	5.0	9.0	9.0	9.0
865	PI 278025	Turkey	8.2	9.0	8.3	9.0	5.0	9.0	9.0	9.0
866	PI 559992	Nigeria	8.2	9.0	8.3	9.0	5.0	9.0	9.0	9.0
867	PI 482291	Zimbabwe	8.2	9.0	8.3	9.0	6.0	9.0	9.0	8.0
868	PI 169274	Turkey	8.2	9.0	8.3	9.0	5.0	9.0	9.0	9.0
869	PI 182181	Turkey	8.2	9.0	8.3	9.0	5.0	9.0	9.0	9.0
870	PI 169296	Turkey	8.2	9.0	8.4	9.0	5.0	9.0	9.0	9.0
871	PI 512404	Spain	8.2	9.0	8.4	9.0	5.0	9.0	9.0	9.0
872	PI 172786	Turkey	8.2	9.0	8.4	9.0	5.0	9.0	9.0	9.0
873	PI 222778	Iran	8.2	9.0	8.4	9.0	5.0	9.0	9.0	9.0
874	PI 214316	India	8.2	9.0	8.5	9.0	5.0	9.0	9.0	9.0
875	Charleston Gray, Check		8.2	8.9	8.0	8.3	7.0	9.0	9.0	8.3

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
876	PI 271776	S.Africa	8.3	9.0	7.6	7.0	-	9.0	9.0	8.0
877	PI 176914	Turkey	8.3	9.0	7.7	-	6.0	9.0	9.0	9.0
878	PI 357694	Yugoslavia	8.3	9.0	7.9	-	6.0	9.0	9.0	9.0
879	PI 435990	China	8.3	9.0	8.0	-	6.0	9.0	9.0	9.0
880	PI 254738	Senegal	8.3	9.0	8.0	9.0	6.0	9.0	-	9.0
881	PI 381740	India	8.3	9.0	8.1	9.0	6.0	9.0	9.0	-
882	PI 357658	Yugoslavia	8.3	9.0	8.1	9.0	6.0	9.0	9.0	-
883	PI 185636	Ghana	8.3	9.0	8.1	-	6.0	9.0	9.0	9.0
884	PI 176910	Turkey	8.3	9.0	8.3	-	7.0	9.0	9.0	8.0
885	PI 542114	Botswana	8.3	9.0	8.3	9.0	6.0	-	9.0	9.0
886	PI 270145	Greece	8.3	9.0	8.4	9.0	6.0	9.0	9.0	-
887	PI 219906	Afghanistan	8.3	9.0	8.4	-	6.0	9.0	9.0	9.0
888	PI 357677	Yugoslavia	8.3	9.0	7.4	9.0	7.0	-	-	9.0
889	PI 226634	Iran	8.3	9.0	7.8	-	7.0	9.0	9.0	-
890	PI 223765	Afghanistan	8.3	9.0	7.8	-	7.0	9.0	9.0	-
891	PI 512367	Spain	8.3	9.0	8.1	9.0	7.0	-	9.0	-
892	PI 296334	S.Africa	8.3	9.0	8.2	8.0	-	9.0	-	8.0
893	PI 216029	India	8.4	9.0	7.5	9.0	6.0	9.0	9.0	9.0
894	PI 169255	Turkey	8.4	9.0	7.5	9.0	6.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
895	PI 500341	Zambia	8.4	9.0	7.7	9.0	7.0	9.0	9.0	8.0
896	PI 512385	Spain	8.4	9.0	7.8	9.0	6.0	9.0	9.0	9.0
897	PI 482313	Zimbabwe	8.4	9.0	7.9	9.0	6.0	9.0	9.0	9.0
898	PI 482321	Zimbabwe	8.4	9.0	7.9	8.0	7.0	9.0	9.0	9.0
899	PI 482281	Zimbabwe	8.4	9.0	7.9	9.0	7.0	9.0	9.0	8.0
900	PI 169288	Turkey	8.4	9.0	7.9	9.0	6.0	9.0	9.0	9.0
901	PI 183673	Turkey, Ankara	8.4	9.0	7.9	9.0	7.0	9.0	9.0	8.0
902	PI 169287	Turkey	8.4	9.0	7.9	9.0	7.0	9.0	9.0	8.0
903	PI 537461	Spain	8.4	9.0	7.9	9.0	6.0	9.0	9.0	9.0
904	PI 193964	Ethiopia	8.4	9.0	8.0	9.0	6.0	9.0	9.0	9.0
905	PI 266028	Venezuela	8.4	9.0	8.0	9.0	6.0	9.0	9.0	9.0
906	PI 278057	Turkey	8.4	9.0	8.0	9.0	6.0	9.0	9.0	9.0
907	PI 368513	Yugoslavia	8.4	9.0	8.0	9.0	6.0	9.0	9.0	9.0
908	PI 379248	Yugoslavia	8.4	9.0	8.0	9.0	7.0	9.0	9.0	8.0
909	PI 500305	Zambia	8.4	9.0	8.0	9.0	6.0	9.0	9.0	9.0
910	PI 307748	Philippines	8.4	9.0	8.0	9.0	9.0	9.0	9.0	6.0
911	PI 179880	India	8.4	9.0	8.0	9.0	6.0	9.0	9.0	9.0
912	PI 559996	Nigeria	8.4	9.0	8.1	9.0	6.0	9.0	9.0	9.0
913	PI 507863	Hungary	8.4	9.0	8.1	9.0	6.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
914	PI 163202	India	8.4	9.0	8.1	9.0	7.0	9.0	9.0	8.0
915	Grif 1734	China	8.4	9.0	8.1	9.0	7.0	9.0	9.0	8.0
916	PI 174109	Turkey	8.4	9.0	8.1	9.0	6.0	9.0	9.0	9.0
917	PI 458739	Paraguay	8.4	9.0	8.2	9.0	6.0	9.0	9.0	9.0
918	PI 482246	Zimbabwe	8.4	9.0	8.2	9.0	7.0	9.0	9.0	8.0
919	PI 172791	Turkey	8.4	9.0	8.2	9.0	6.0	9.0	9.0	9.0
920	PI 274785	India	8.4	9.0	8.2	9.0	6.0	9.0	9.0	9.0
921	PI 278028	Turkey	8.4	9.0	8.3	9.0	9.0	9.0	9.0	6.0
922	PI 227202	Japan	8.4	9.0	8.3	9.0	6.0	9.0	9.0	9.0
923	Grif 5599	India	8.4	9.0	8.3	9.0	6.0	9.0	9.0	9.0
924	PI 169268	Turkey	8.4	9.0	8.4	9.0	6.0	9.0	9.0	9.0
925	PI 254622	Sudan	8.4	9.0	8.4	9.0	6.0	9.0	9.0	9.0
926	PI 490380	Mali	8.4	9.0	8.4	9.0	6.0	9.0	9.0	9.0
927	PI 182933	India	8.4	9.0	8.4	9.0	6.0	9.0	9.0	9.0
928	PI 368514	Yugoslavia	8.4	9.0	8.4	9.0	6.0	9.0	9.0	9.0
929	PI 381734	India	8.4	9.0	8.4	9.0	6.0	9.0	9.0	9.0
930	PI 229686	Iran	8.4	9.0	8.5	9.0	6.0	9.0	9.0	9.0
931	PI 482338	Zimbabwe	8.4	9.0	8.5	9.0	6.0	9.0	9.0	9.0
932	PI 271773	S. Africa	8.4	9.0	8.5	9.0	6.0	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
933	PI 357678	Yugoslavia	8.5	9.0	7.6	9.0	8.0	-	-	-
934	PI 273481	Ethiopia	8.5	9.0	7.8	-	8.0	9.0	9.0	8.0
935	PI 171583	Turkey	8.5	9.0	7.8	9.0	7.0	9.0	-	9.0
936	PI 113326	China	8.5	9.0	7.9	9.0	7.0	-	9.0	9.0
937	PI 222710	Iran	8.5	9.0	8.0	9.0	-	-	-	8.0
938	PI 169277	Turkey	8.5	9.0	8.1	9.0	8.0	-	-	-
939	PI 494527	Nigeria	8.5	9.0	8.1	7.0	-	9.0	9.0	9.0
940	PI 482335	Zimbabwe	8.5	9.0	8.2	8.0	8.0	-	9.0	9.0
941	PI 500314	Zambia	8.5	9.0	8.2	9.0	7.0	9.0	9.0	-
942	PI 169233	Turkey	8.5	9.0	8.2	9.0	7.0	9.0	-	9.0
943	PI 270524	Israel	8.5	9.0	8.4	8.0	-	-	9.0	-
944	PI 226445	Israel	8.5	9.0	8.4	9.0	7.0	-	9.0	9.0
945	PI 357734	Yugoslavia	8.5	9.0	8.4	-	-	9.0	-	8.0
946	PI 271769	S.Africa	8.5	9.0	8.5	-	8.0	9.0	9.0	8.0
947	PI 482257	Zimbabwe	8.6	9.0	7.8	7.0	9.0	9.0	9.0	9.0
948	PI 174100	Turkey	8.6	9.0	7.9	9.0	8.0	9.0	9.0	8.0
949	PI 357685	Yugoslavia	8.6	9.0	7.9	8.0	8.0	9.0	9.0	9.0
950	PI 254739	Senegal	8.6	9.0	8.0	9.0	8.0	9.0	9.0	8.0
951	PI 249010	Nigeria	8.6	9.0	8.0	9.0	8.0	9.0	9.0	8.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
952	PI 233556	Japan	8.6	9.0	8.0	9.0	7.0	9.0	9.0	9.0
953	PI 255662	Afghanistan	8.6	9.0	8.0	9.0	8.0	9.0	9.0	8.0
954	PI 482307	Zimbabwe	8.6	9.0	8.0	9.0	8.0	9.0	9.0	8.0
955	PI 476330	Soviet Union	8.6	9.0	8.0	8.0	9.0	9.0	9.0	8.0
956	PI 381709	India	8.6	9.0	8.1	9.0	7.0	9.0	9.0	9.0
957	PI 507861	Hungary	8.6	9.0	8.1	9.0	7.0	9.0	9.0	9.0
958	PI 482314	Zimbabwe	8.6	9.0	8.1	9.0	7.0	9.0	9.0	9.0
959	PI 482282	Zimbabwe	8.6	9.0	8.1	9.0	8.0	9.0	9.0	8.0
960	PI 271747	Afghanistan	8.6	9.0	8.1	8.0	8.0	9.0	9.0	9.0
961	PI 169260	Turkey	8.6	9.0	8.1	8.0	9.0	9.0	9.0	8.0
962	PI 512362	Spain	8.6	9.0	8.2	9.0	9.0	9.0	7.0	9.0
963	PI 379239	Yugoslavia	8.6	9.0	8.2	9.0	7.0	9.0	9.0	9.0
964	PI 532816	China	8.6	9.0	8.2	9.0	7.0	9.0	9.0	9.0
965	PI 512384	Spain	8.6	9.0	8.2	8.0	8.0	9.0	9.0	9.0
966	PI 164550	India	8.6	9.0	8.3	9.0	7.0	9.0	9.0	9.0
967	PI 379242	Yugoslavia	8.6	9.0	8.3	9.0	9.0	9.0	9.0	7.0
968	PI 269678	Belize	8.6	9.0	8.3	9.0	8.0	9.0	9.0	8.0
969	PI 507860	Hungary	8.6	9.0	8.4	9.0	7.0	9.0	9.0	9.0
970	PI 381700	India	8.6	9.0	8.4	9.0	7.0	9.0	9.0	9.0

(continued next page)

Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
971	PI 165002	Turkey	8.6	9.0	8.4	9.0	7.0	9.0	9.0	9.0
972	PI 381737	India	8.6	9.0	8.4	9.0	7.0	9.0	9.0	9.0
973	PI 381703	India	8.6	9.0	8.4	9.0	8.0	9.0	9.0	8.0
974	PI 487459	Venezuela	8.6	9.0	8.4	9.0	7.0	9.0	9.0	9.0
975	PI 500331	Zambia	8.6	9.0	8.4	9.0	8.0	9.0	9.0	8.0
976	PI 249009	Nigeria	8.6	9.0	8.4	9.0	9.0	9.0	9.0	7.0
977	PI 379243	Yugoslavia	8.6	9.0	8.5	9.0	7.0	9.0	9.0	9.0
978	PI 482311	Zimbabwe	8.6	9.0	8.5	9.0	7.0	9.0	9.0	9.0
979	PI 357662	Yugoslavia	8.7	8.7	7.6	8.0	-	9.0	9.0	-
980	PI 171587	Turkey	8.7	9.0	7.7	-	-	9.0	9.0	8.0
981	PI 357669	Yugoslavia	8.7	9.0	7.9	9.0	-	-	9.0	8.0
982	PI 175654	Turkey	8.7	9.0	8.1	-	8.0	9.0	-	9.0
983	PI 277970	Turkey	8.7	9.0	8.2	-	8.0	9.0	9.0	-
984	PI 370422	Yugoslavia	8.7	9.0	8.2	-	9.0	9.0	-	8.0
985	PI 293765	Soviet Union	8.7	9.0	8.3	9.0	8.0	-	9.0	-
986	PI 179877	India	8.7	9.0	8.4	-	-	9.0	9.0	8.0
987	PI 379241	Yugoslavia	8.8	9.0	7.5	-	9.0	9.0	9.0	8.0
988	PI 167222	Turkey	8.8	9.0	7.6	9.0	8.0	9.0	9.0	-
989	PI 176493	Turkey	8.8	9.0	7.8	9.0	8.0	-	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
990	PI 222711	Iran	8.8	9.0	7.9	-	8.0	9.0	9.0	9.0
991	PI 169253	Turkey	8.8	9.0	7.9	9.0	-	9.0	9.0	8.0
992	PI 525097	Egypt	8.8	9.0	8.0	9.0	-	9.0	9.0	8.0
993	PI 275632	India	8.8	9.0	8.0	9.0	-	9.0	9.0	8.0
994	PI 357743	Yugoslavia	8.8	9.0	8.1	9.0	9.0	9.0	-	8.0
995	PI 164748	India	8.8	9.0	8.1	9.0	8.0	9.0	9.0	-
996	PI 271987	Somalia	8.8	9.0	8.1	8.0	-	9.0	9.0	9.0
997	PI 534588	Syria	8.8	9.0	8.2	9.0	-	9.0	9.0	8.0
998	PI 518606	Soviet Union	8.8	9.0	8.2	9.0	9.0	9.0	-	8.0
999	PI 179239	Turkey	8.8	9.0	8.2	9.0	8.0	-	9.0	9.0
1000	PI 512343	Spain	8.8	9.0	8.2	9.0	-	9.0	9.0	8.0
1001	PI 171582	Turkey	8.8	9.0	8.3	9.0	-	9.0	9.0	8.0
1002	PI 379222	Yugoslavia	8.8	9.0	8.3	9.0	9.0	-	9.0	8.0
1003	PI 271982	Somalia	8.8	9.0	8.3	9.0	-	9.0	9.0	8.0
1004	PI 481871	Sudan	8.8	9.0	8.3	9.0	-	9.0	9.0	8.0
1005	PI 512355	Spain	8.8	9.0	8.5	9.0	-	9.0	9.0	8.0
1006	PI 176922	Turkey	8.8	9.0	8.5	9.0	-	9.0	9.0	8.0
1007	PI 482279	Zimbabwe	8.8	9.0	8.6	-	8.0	9.0	9.0	9.0
1008	PI 181868	Syria	8.8	9.0	8.6	9.0	-	9.0	9.0	8.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
1009	PI 368500	Yugoslavia	8.8	9.0	8.0	9.0	9.0	9.0	9.0	8.0
1010	PI 534599	Syria	8.8	9.0	8.1	9.0	9.0	9.0	9.0	8.0
1011	PI 167126	Turkey	8.8	9.0	8.1	9.0	8.0	9.0	9.0	9.0
1012	Grif 1731	China	8.8	9.0	8.2	9.0	9.0	9.0	9.0	8.0
1013	PI 179232	Turkey	8.8	9.0	8.2	9.0	9.0	9.0	9.0	8.0
1014	PI 536452	Maldives	8.8	9.0	8.3	9.0	8.0	9.0	9.0	9.0
1015	PI 479704	USA	8.8	9.0	8.3	9.0	9.0	9.0	9.0	8.0
1016	PI 164633	India	8.8	9.0	8.3	9.0	8.0	9.0	9.0	9.0
1017	PI 179238	Turkey	8.8	9.0	8.3	9.0	8.0	9.0	9.0	9.0
1018	PI 169264	Turkey	8.8	9.0	8.3	9.0	9.0	9.0	9.0	8.0
1019	PI 161373	S. Korea	8.8	9.0	8.3	8.0	9.0	9.0	9.0	9.0
1020	PI 368521	Yugoslavia	8.8	9.0	8.4	9.0	8.0	9.0	9.0	9.0
1021	PI 379236	Yugoslavia	8.8	9.0	8.4	9.0	9.0	9.0	9.0	8.0
1022	PI 222714	Iran	8.8	9.0	8.4	9.0	9.0	9.0	9.0	8.0
1023	PI 269464	Pakistan	8.8	9.0	8.4	8.0	9.0	9.0	9.0	9.0
1024	PI 500338	Zambia	8.8	9.0	8.4	9.0	8.0	9.0	9.0	9.0
1025	PI 494530	Nigeria	8.8	9.0	8.4	8.0	9.0	9.0	9.0	9.0
1026	PI 174099	Turkey	8.8	9.0	8.4	9.0	8.0	9.0	9.0	9.0
1027	PI 507867	Hungary	8.8	9.0	8.4	9.0	9.0	9.0	9.0	8.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
1028	PI 179885	India	8.8	9.0	8.4	9.0	8.0	9.0	9.0	9.0
1029	PI 381704	India	8.8	9.0	8.5	9.0	8.0	9.0	9.0	9.0
1030	PI 279458	Japan	8.8	9.0	8.5	9.0	8.0	9.0	9.0	9.0
1031	PI 507869	Hungary	8.8	9.0	8.5	9.0	8.0	9.0	9.0	9.0
1032	PI 379251	Yugoslavia	8.8	9.0	8.5	9.0	8.0	9.0	9.0	9.0
1033	PI 500329	Zambia	8.8	9.0	8.5	9.0	8.0	9.0	9.0	9.0
1034	PI 254737	Senegal	9.0	9.0	6.7	9.0	-	-	-	-
1035	PI 357710	Yugoslavia	9.0	9.0	6.7	9.0	-	-	-	-
1036	PI 278010	Turkey	9.0	9.0	6.8	-	-	-	9.0	-
1037	PI 357682	Yugoslavia	9.0	9.0	7.5	-	9.0	-	-	-
1038	PI 344300	Turkey	9.0	9.0	7.6	-	9.0	-	9.0	-
1039	PI 534590	Syria	9.0	9.0	7.7	-	-	9.0	-	-
1040	PI 306367	Angola	9.0	9.0	7.8	-	-	9.0	9.0	-
1041	PI 278021	Turkey	9.0	9.0	7.8	-	-	9.0	-	-
1042	PI 175660	Turkey	9.0	9.0	8.0	9.0	9.0	-	9.0	9.0
1043	PI 169261	Turkey	9.0	9.0	8.0	9.0	9.0	9.0	9.0	-
1044	PI 178870	Turkey	9.0	9.0	8.0	9.0	-	-	9.0	9.0
1045	PI 344395	Iran	9.0	9.0	8.0	-	-	-	9.0	-
1046	PI 346787	USA	9.0	9.0	8.0	-	-	9.0	-	-

(continued next page)

Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
1047	PI 271771	S.Africa	9.0	9.0	8.0	9.0	-	-	-	-
1048	PI 270523	USA	9.0	9.0	8.0	-	9.0	9.0	9.0	9.0
1049	PI 277985	Turkey	9.0	9.0	8.1	-	-	9.0	9.0	9.0
1050	PI 532809	China	9.0	9.0	8.1	9.0	-	9.0	9.0	9.0
1051	PI 176905	Turkey	9.0	9.0	8.1	-	-	-	9.0	9.0
1052	PI 482354	Zimbabwe	9.0	9.0	8.1	-	-	9.0	-	9.0
1053	PI 288317	India	9.0	9.0	8.1	9.0	9.0	-	-	9.0
1054	PI 173670	Turkey	9.0	9.0	8.1	9.0	-	9.0	9.0	-
1055	PI 381725	India	9.0	9.0	8.1	9.0	-	9.0	9.0	-
1056	PI 183299	India	9.0	9.0	8.1	9.0	9.0	9.0	9.0	9.0
1057	PI 185030	Turkey	9.0	9.0	8.2	9.0	-	9.0	-	9.0
1058	PI 357705	Yugoslavia	9.0	9.0	8.2	9.0	9.0	-	9.0	9.0
1059	PI 207471	Afghanistan	9.0	9.0	8.2	-	-	-	-	9.0
1060	PI 169271	Turkey	9.0	9.0	8.2	9.0	-	9.0	9.0	9.0
1061	PI 379253	Yugoslavia	9.0	9.0	8.2	9.0	9.0	9.0	9.0	9.0
1062	PI 512383	Spain	9.0	9.0	8.2	9.0	9.0	9.0	9.0	9.0
1063	PI 512381	Spain	9.0	9.0	8.2	9.0	-	9.0	9.0	-
1064	PI 357666	Yugoslavia	9.0	9.0	8.2	9.0	-	9.0	9.0	9.0
1065	PI 379254	Yugoslavia	9.0	9.0	8.2	9.0	9.0	-	9.0	9.0

(continued next page)

Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
1066	PI 512332	China	9.0	9.0	8.2	9.0	-	-	9.0	9.0
1067	PI 176913	Turkey	9.0	9.0	8.2	9.0	-	9.0	9.0	-
1068	PI 169270	Turkey	9.0	9.0	8.2	9.0	9.0	9.0	9.0	9.0
1069	PI 217937	Pakistan	9.0	9.0	8.2	-	-	9.0	9.0	9.0
1070	PI 278046	Turkey	9.0	9.0	8.2	-	-	9.0	9.0	9.0
1071	PI 270144	Greece	9.0	9.0	8.2	9.0	-	9.0	9.0	9.0
1072	PI 525081	Egypt	9.0	9.0	8.3	-	-	9.0	-	9.0
1073	PI 508443	South Korea	9.0	9.0	8.3	-	-	9.0	9.0	-
1074	PI 370434	Yugoslavia	9.0	9.0	8.3	-	9.0	9.0	9.0	9.0
1075	PI 500340	Zambia	9.0	9.0	8.3	9.0	9.0	-	9.0	-
1076	PI 512361	Spain	9.0	9.0	8.3	-	9.0	9.0	9.0	9.0
1077	PI 178877	Turkey	9.0	9.0	8.3	9.0	9.0	9.0	9.0	9.0
1078	PI 296384	Iran	9.0	9.0	8.3	9.0	-	9.0	9.0	-
1079	PI 500319	Zambia	9.0	9.0	8.3	9.0	-	9.0	9.0	9.0
1080	PI 169244	Turkey	9.0	9.0	8.3	9.0	9.0	9.0	9.0	9.0
1081	PI 222775	Iran	9.0	9.0	8.3	-	-	9.0	-	-
1082	PI 169290	Turkey	9.0	9.0	8.3	-	-	9.0	9.0	-
1083	PI 227205	Japan	9.0	9.0	8.3	-	-	9.0	9.0	9.0
1084	PI 169272	Turkey	9.0	9.0	8.3	9.0	-	9.0	9.0	-

(continued next page)

Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
1085	PI 277977	Turkey	9.0	9.0	8.3	9.0	9.0	-	-	9.0
1086	PI 211851	Iran	9.0	9.0	8.3	9.0	-	9.0	9.0	9.0
1087	PI 164804	India	9.0	9.0	8.4	9.0	-	9.0	9.0	9.0
1088	PI 560016	Nigeria	9.0	9.0	8.4	9.0	9.0	9.0	9.0	9.0
1089	PI 207473	Afghanistan	9.0	9.0	8.4	-	9.0	9.0	9.0	-
1090	PI 278020	Turkey	9.0	9.0	8.4	9.0	-	-	-	-
1091	PI 368495	Yugoslavia	9.0	9.0	8.4	9.0	9.0	9.0	9.0	9.0
1092	PI 431579	India	9.0	9.0	8.4	9.0	-	9.0	9.0	9.0
1093	PI 172800	Turkey	9.0	9.0	8.4	9.0	-	9.0	9.0	9.0
1094	PI 270308	Philippines	9.0	9.0	8.4	-	9.0	-	9.0	-
1095	PI 357727	Yugoslavia	9.0	9.0	8.4	9.0	9.0	9.0	9.0	9.0
1096	PI 176496	Turkey	9.0	9.0	8.4	9.0	-	9.0	9.0	-
1097	PI 381696	India	9.0	9.0	8.4	9.0	9.0	9.0	9.0	9.0
1098	PI 502318	Uzbekistan	9.0	9.0	8.4	9.0	9.0	9.0	9.0	9.0
1099	PI 512379	Spain	9.0	9.0	8.4	9.0	9.0	-	9.0	-
1100	PI 176485	Turkey	9.0	9.0	8.4	9.0	9.0	9.0	9.0	9.0
1101	PI 176921	Turkey	9.0	9.0	8.4	9.0	9.0	9.0	9.0	9.0
1102	PI 269679	Belize	9.0	9.0	8.4	-	-	9.0	9.0	9.0
1103	PI 368497	Yugoslavia	9.0	9.0	8.5	9.0	9.0	9.0	9.0	9.0

(continued next page)

Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
1104	PI 368515	Yugoslavia	9.0	9.0	8.5	9.0	9.0	9.0	9.0	9.0
1105	PI 175662	Turkey	9.0	9.0	8.5	9.0	-	9.0	9.0	9.0
1106	PI 379245	Yugoslavia	9.0	9.0	8.5	9.0	9.0	9.0	9.0	9.0
1107	PI 178873	Turkey	9.0	9.0	8.5	9.0	9.0	9.0	9.0	9.0
1108	PI 279461	Japan	9.0	9.0	8.5	9.0	9.0	9.0	9.0	9.0
1109	PI 176490	Turkey	9.0	9.0	8.5	9.0	9.0	9.0	9.0	9.0
1110	PI 500309	Zambia	9.0	9.0	8.5	9.0	9.0	9.0	9.0	9.0
1111	PI 319237	Japan	9.0	9.0	8.5	9.0	-	-	-	9.0
1112	PI 508442	S.Korea	9.0	9.0	8.5	9.0	9.0	9.0	9.0	9.0
1113	PI 176908	Turkey	9.0	9.0	8.5	9.0	-	9.0	9.0	9.0
1114	PI 494532	Nigeria	9.0	9.0	8.5	9.0	-	9.0	9.0	9.0
1115	PI 368518	Yugoslavia	9.0	9.0	8.5	-	-	9.0	9.0	9.0
1116	PI 179233	Turkey	9.0	9.0	8.5	-	9.0	9.0	9.0	9.0
1117	Grif 1728	China	9.0	9.0	8.5	-	-	-	9.0	-
1118	PI 418762	Afghanistan	9.0	9.0	8.5	-	-	-	9.0	-
1119	PI 319235	Japan	9.0	9.0	8.5	-	-	9.0	-	-
1120	PI 345545	Soviet Union	9.0	9.0	8.5	9.0	-	9.0	-	-
1121	PI 512833	Spain	9.0	9.0	8.5	9.0	-	9.0	-	9.0
1122	PI 164146	India	9.0	9.0	8.5	9.0	9.0	-	9.0	9.0

(continued next page)

Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
1123	PI 482289	Zimbabwe	9.0	9.0	8.5	9.0	-	9.0	9.0	9.0
1124	PI 357690	Yugoslavia	9.0	9.0	8.5	9.0	9.0	9.0	9.0	9.0
1125	PI 171392	S.Africa	9.0	9.0	8.5	9.0	-	9.0	9.0	9.0
1126	PI 490377	Mali	9.0	9.0	8.5	9.0	-	9.0	9.0	9.0
1127	PI 357707	Yugoslavia	9.0	9.0	8.5	9.0	-	9.0	9.0	-
1128	PI 357735	Yugoslavia	9.0	9.0	8.6	9.0	9.0	9.0	9.0	9.0
1129	PI 247398	Greece	9.0	9.0	8.6	9.0	-	9.0	-	9.0
1130	PI 278011	Turkey	9.0	9.0	8.6	9.0	-	-	9.0	-
1131	PI 278027	Turkey	9.0	9.0	8.6	9.0	9.0	9.0	9.0	9.0
1132	PI 378612	Zaire	9.0	9.0	8.6	9.0	-	9.0	9.0	9.0
1133	PI 512358	Spain	9.0	9.0	8.6	9.0	-	9.0	9.0	9.0
1134	PI 379246	Yugoslavia	9.0	9.0	8.6	9.0	9.0	9.0	9.0	-
1135	PI 357675	Yugoslavia	9.0	9.0	8.6	9.0	-	9.0	9.0	9.0
1136	PI 176915	Turkey	9.0	9.0	8.6	-	-	9.0	9.0	-
1137	PI 271466	India	9.0	9.0	8.6	9.0	-	9.0	9.0	9.0
1138	PI 169292	Turkey	9.0	9.0	8.6	9.0	-	9.0	-	9.0
1139	PI 507859	Hungary	9.0	9.0	8.6	9.0	9.0	9.0	9.0	9.0
1140	PI 195928	Ethiopia	9.0	9.0	8.6	9.0	9.0	9.0	9.0	9.0
1141	PI 185635	Ghana	9.0	9.0	8.6	9.0	-	-	-	-

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
1142	PI 357671	Yugoslavia	9.0	9.0	8.6	9.0	-	9.0	9.0	-
1143	PI 175661	Turkey	9.0	9.0	8.6	-	-	9.0	9.0	9.0
1144	PI 344301	Turkey	9.0	9.0	8.6	9.0	9.0	-	9.0	9.0
1145	PI 271774	S.Africa	9.0	9.0	8.6	9.0	9.0	9.0	9.0	-
1146	PI 173668	Turkey	9.0	9.0	8.6	9.0	-	-	9.0	-
1147	PI 211849	Iran	9.0	9.0	8.6	9.0	-	-	9.0	9.0
1148	PI 500304	Zambia	9.0	9.0	8.7	9.0	-	-	9.0	-
1149	PI 532817	China	9.0	9.0	8.7	9.0	9.0	9.0	9.0	9.0
1150	PI 169242	Turkey	9.0	9.0	8.7	9.0	-	9.0	9.0	-
1151	PI 490378	Mali	9.0	9.0	8.7	9.0	-	9.0	9.0	-
1152	PI 490379	Mali	9.0	9.0	8.7	9.0	-	9.0	9.0	-
1153	PI 512359	Spain	9.0	9.0	8.7	9.0	9.0	9.0	9.0	-
1154	PI 176499	Turkey	9.0	9.0	8.7	9.0	9.0	9.0	9.0	9.0
1155	PI 500332	Zambia	9.0	9.0	8.7	9.0	9.0	9.0	9.0	9.0
1156	PI 181744	Lebanon	9.0	9.0	8.7	-	-	-	9.0	-
1157	PI 325248	Soviet Union	9.0	9.0	8.7	-	-	-	9.0	-
1158	PI 254744	Senegal	9.0	9.0	8.7	-	-	9.0	-	-
1159	PI 534591	Syria	9.0	9.0	8.7	9.0	-	9.0	9.0	-
1160	PI 512391	Spain	9.0	9.0	8.7	9.0	-	9.0	9.0	9.0

(continued next page)

Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
1161	PI 172787	Turkey	9.0	9.0	8.7	9.0	9.0	9.0	-	-
1162	PI 240532	Iran	9.0	9.0	8.7	-	-	-	9.0	9.0
1163	PI 228238	Israel	9.0	9.0	8.7	-	-	9.0	9.0	-
1164	PI 278053	Turkey	9.0	9.0	8.7	9.0	-	9.0	-	-
1165	PI 296337	S.Africa	9.0	9.0	8.7	9.0	-	9.0	9.0	9.0
1166	PI 169283	Turkey	9.0	9.0	8.7	9.0	-	9.0	9.0	9.0
1167	PI 179661	India	9.0	9.0	8.7	9.0	-	9.0	9.0	9.0
1168	PI 295850	S.Africa	9.0	9.0	8.7	9.0	-	9.0	9.0	9.0
1169	PI 357683	Yugoslavia	9.0	9.0	8.7	9.0	-	9.0	9.0	-
1170	PI 179662	India	9.0	9.0	8.7	9.0	-	9.0	9.0	9.0
1171	PI 357701	Yugoslavia	9.0	9.0	8.7	-	-	9.0	9.0	9.0
1172	PI 381720	India	9.0	9.0	8.7	-	-	9.0	9.0	9.0
1173	PI 369220	Soviet Union	9.0	9.0	8.7	9.0	-	-	9.0	9.0
1174	PI 368516	Yugoslavia	9.0	9.0	8.7	9.0	-	9.0	-	9.0
1175	PI 277279	India	9.0	9.0	8.7	9.0	-	9.0	9.0	-
1176	PI 357699	Yugoslavia	9.0	9.0	8.7	9.0	-	9.0	9.0	-
1177	PI 176911	Turkey	9.0	9.0	8.7	9.0	-	9.0	9.0	-
1178	PI 357745	Yugoslavia	9.0	9.0	8.7	9.0	-	-	9.0	-
1179	PI 169252	Turkey	9.0	9.0	8.7	9.0	-	9.0	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
1180	PI 183399	India	9.0	9.0	8.7	9.0	-	9.0	9.0	9.0
1181	PI 357728	Yugoslavia	9.0	9.0	8.7	9.0	-	9.0	9.0	9.0
1182	PI 270565	S. Africa	9.0	9.0	8.8	9.0	-	-	9.0	-
1183	PI 277988	Turkey	9.0	9.0	8.8	9.0	-	-	9.0	-
1184	PI 278006	Turkey	9.0	9.0	8.8	9.0	-	9.0	-	-
1185	PI 278047	Turkey	9.0	9.0	8.8	9.0	-	9.0	-	-
1186	PI 357663	Yugoslavia	9.0	9.0	8.8	9.0	-	9.0	-	-
1187	PI 357692	Yugoslavia	9.0	9.0	8.8	9.0	-	9.0	9.0	9.0
1188	PI 512407	Spain	9.0	9.0	8.8	9.0	-	9.0	9.0	9.0
1189	PI 183125	India	9.0	9.0	8.8	9.0	-	-	9.0	9.0
1190	PI 357686	Yugoslavia	9.0	9.0	8.8	9.0	-	9.0	9.0	-
1191	PI 169258	Turkey	9.0	9.0	8.8	9.0	-	9.0	9.0	9.0
1192	PI 234603	New Zealand	9.0	9.0	8.8	9.0	-	9.0	9.0	9.0
1193	PI 357698	Yugoslavia	9.0	9.0	8.8	9.0	-	9.0	9.0	9.0
1194	PI 288316	India	9.0	9.0	8.8	9.0	-	-	-	-
1195	PI 357706	Yugoslavia	9.0	9.0	8.8	9.0	-	-	-	-
1196	PI 278044	Turkey	9.0	9.0	8.8	9.0	-	-	9.0	9.0
1197	PI 357736	Yugoslavia	9.0	9.0	8.8	9.0	-	9.0	9.0	9.0
1198	PI 277993	Turkey	9.0	9.0	8.8	-	-	-	9.0	9.0

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
1199	PI 177324	Turkey	9.0	9.0	8.8	-	-	9.0	-	9.0
1200	PI 176923	Turkey	9.0	9.0	8.8	-	-	9.0	9.0	-
1201	PI 357730	Yugoslavia	9.0	9.0	8.8	9.0	-	-	9.0	-
1202	PI 370428	Yugoslavia	9.0	9.0	8.8	9.0	-	-	9.0	-
1203	PI 512393	Spain	9.0	9.0	8.8	9.0	-	-	9.0	-
1204	PI 331106	Uruguay	9.0	9.0	8.8	-	-	-	9.0	-
1205	PI 182183	Turkey	9.0	9.0	8.8	-	-	9.0	-	-
1206	PI 278030	Turkey	9.0	9.0	8.8	-	-	9.0	-	-
1207	PI 279456	Japan	9.0	9.0	8.8	-	-	9.0	-	-
1208	PI 254428	Lebanon	9.0	9.0	8.8	9.0	-	9.0	9.0	-
1209	PI 169245	Turkey	9.0	9.0	8.8	9.0	-	9.0	9.0	9.0
1210	PI 490382	Mali	9.0	9.0	8.8	9.0	-	9.0	9.0	9.0
1211	PI 378613	Zaire	9.0	9.0	8.8	9.0	9.0	9.0	9.0	-
1212	PI 211852	Iran	9.0	9.0	8.9	9.0	-	-	9.0	9.0
1213	PI 277991	Turkey	9.0	9.0	8.9	9.0	-	9.0	9.0	-
1214	PI 288522	India	9.0	9.0	8.9	9.0	-	9.0	9.0	-
1215	PI 381713	India	9.0	9.0	8.9	9.0	-	9.0	9.0	-
1216	PI 172798	Turkey	9.0	9.0	8.9	9.0	-	-	-	9.0
1217	PI 183217	Egypt	9.0	9.0	8.9	9.0	-	9.0	-	-

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
1218	PI 296342	S.Africa	9.0	9.0	8.9	9.0	-	9.0	9.0	9.0
1219	PI 357737	Yugoslavia	9.0	9.0	8.9	9.0	-	-	9.0	-
1220	PI 278018	Turkey	9.0	9.0	8.9	9.0	-	-	9.0	9.0
1221	PI 270563	S. Africa	9.0	9.0	9.0	-	-	-	-	9.0
1222	PI 277971	Turkey	9.0	9.0	9.0	-	-	-	-	9.0
1223	PI 532670	Botswana	9.0	9.0	9.0	-	-	-	-	9.0
1224	PI 212209	Greece	9.0	9.0	9.0	-	-	-	9.0	-
1225	PI 225557	Zimbabwe	9.0	9.0	9.0	-	-	-	9.0	-
1226	PI 247399	Greece	9.0	9.0	9.0	-	-	-	9.0	-
1227	PI 273480	Ethiopia	9.0	9.0	9.0	-	-	-	9.0	-
1228	PI 277986	Turkey	9.0	9.0	9.0	-	-	-	9.0	-
1229	PI 169299	Turkey	9.0	9.0	9.0	-	-	9.0	-	-
1230	PI 181938	Syria	9.0	9.0	9.0	-	-	9.0	-	-
1231	PI 271767	S.Africa	9.0	9.0	9.0	-	-	9.0	-	-
1232	PI 278013	Turkey	9.0	9.0	9.0	-	-	9.0	-	-
1233	PI 278049	Turkey	9.0	9.0	9.0	-	-	9.0	-	-
1234	PI 344066	Turkey	9.0	9.0	9.0	-	-	9.0	-	-
1235	PI 276659	Soviet Union	9.0	9.0	9.0	9.0	-	-	-	-
1236	PI 277999	Turkey	9.0	9.0	9.0	9.0	-	-	-	-

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
1237	PI 278015	Turkey	9.0	9.0	9.0	9.0	-	-	-	-
1238	PI 290855	USA	9.0	9.0	9.0	9.0	-	-	-	-
1239	PI 296341	S.Africa	9.0	9.0	9.0	9.0	-	-	-	-
1240	PI 542123	Botswana	9.0	9.0	9.0	9.0	-	-	-	-
1241	PI 357680	Yugoslavia	9.0	9.0	9.0	9.0	-	-	-	9.0
1242	PI 279462	Japan	9.0	9.0	9.0	9.0	-	-	9.0	9.0
1243	PI 169263	Turkey	9.0	9.0	9.0	9.0	-	9.0	-	-
1244	PI 177323	Turkey	9.0	9.0	9.0	9.0	-	9.0	-	-
1245	PI 278003	Turkey	9.0	9.0	9.0	9.0	-	9.0	-	-
1246	PI 278038	Turkey	9.0	9.0	9.0	9.0	-	9.0	-	-
1247	PI 368524	Yugoslavia	9.0	9.0	9.0	9.0	-	9.0	-	-
1248	PI 532664	Swaziland	9.0	9.0	9.0	9.0	-	9.0	-	-
1249	PI 182178	Turkey	-	-	-	-	-	-	-	-
1250	PI 182934	India	-	-	-	-	-	-	-	-
1251	PI 241689	Chile	-	-	-	-	-	-	-	-
1252	PI 251796	Yugoslavia	-	-	-	-	-	-	-	-
1253	PI 254429	Lebanon	-	-	-	-	-	-	-	-
1254	PI 260733	Sudan	-	-	-	-	-	-	-	-
1255	PI 266027	Venezuela	-	-	-	-	-	-	-	-

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Appendix table 1. (continued)

Rank	Accession name	Seed source	Virus rating			Best rating for replication				
			Best	Maximum	Average	Rp1	Rp2	Rp3	Rp4	Rp5
1256	PI 271468	India	-	-	-	-	-	-	-	-
1257	PI 274034	S. Africa	-	-	-	-	-	-	-	-
1258	PI 277978	Turkey	-	-	-	-	-	-	-	-
1259	PI 277981	Turkey	-	-	-	-	-	-	-	-
1260	PI 277983	Turkey	-	-	-	-	-	-	-	-
1261	PI 277992	Turkey	-	-	-	-	-	-	-	-
1262	PI 278004	Turkey	-	-	-	-	-	-	-	-
1263	PI 278022	Turkey	-	-	-	-	-	-	-	-
1264	PI 278043	Turkey	-	-	-	-	-	-	-	-
1265	PI 278050	Turkey	-	-	-	-	-	-	-	-
1266	PI 278055	Turkey	-	-	-	-	-	-	-	-
1267	PI 278060	Turkey	-	-	-	-	-	-	-	-
1268	PI 306782	Nigeria	-	-	-	-	-	-	-	-
1269	PI 307608	Nigeria	-	-	-	-	-	-	-	-
1270	PI 314148	Soviet Union	-	-	-	-	-	-	-	-
1271	PI 314178	Soviet Union	-	-	-	-	-	-	-	-
1272	PI 345547	Soviet Union	-	-	-	-	-	-	-	-
1273	PI 357697	Yugoslavia	-	-	-	-	-	-	-	-
1274	PI 385964	Kenya	-	-	-	-	-	-	-	-
1275	PI 532669	Botswana	-	-	-	-	-	-	-	-
LSD (5%)			1.8	0.6	1.1	-	-	-	-	-

[z] Best rating refers to the third ratings for each replication. Plants were rated on a scale of 0-9 on the basis of severity of viral symptoms, where 0=none, 1-2=tendrils absent, 3=tendrils absent, slightly stunted

growth, 4=mosaic leaves and/or necrotic spots on leaves, 5=leaves near apical meristem deformed, meristem yellow and reduced in size, 6=apical meristem withered and brown, 7=apical meristem dead with more basal leaves dying, 8=most leaves dead, main stem green/yellow, 9=plant dead. Best is the average of rating 3 for the 5 replications. Maximum is the average of rating 6 for all of the replications. Average is the overall average of all the ratings for all the replications.

Appendix table 2. ANOVA for the complete data set (199 cultigens including the checks) of the watermelon PI accessions and watermelon cultivars tested for PRSV-W resistance in the greenhouse with 4 replications.

		Mean square (summary)			Mean square (rating date)		
Source	df	Best	Max.	Average	1	2	3
Cultigens	158	1.294	1.294	1.680	2.108	2.085	1.294
Error	380	0.230	0.230	0.370	0.640	0.566	0.230
F ratio (cultigens)		5.62*	5.62*	4.54*	3.29*	3.68*	5.62*

* F ratio significant at 0.01 level.

Appendix table 3. ANOVA for the complete data set (1654 cultigens including checks) of the watermelon PI accessions and watermelon cultivars tested for ZYMV resistance in the greenhouse with 4 replications.

		Mean square (summary)			Mean square (rating date)		
Source	df	Best	Max.	Average	1	2	3
Cultigens	1641	4.314	4.314	3.628	3.263	4.003	4.314
Error	4733	0.321	0.321	0.273	0.481	0.478	0.321
F ratio (cultigens)		13.44*	13.45*	13.28*	6.78*	8.37*	13.44*

*F ratio significant at 0.01 level.

Appendix table 4. Best resistance ratings of 1654 watermelon cultigens inoculated with ZYMV in the screening study.[+]

Rank	Accession or cultivar	Country of origin	Virus rating Best	Average	Max.	Virus rating Rep1	Rep2	Rep3	Rep4
1	PI 537277	Pakistan	0.0	0.0	0.0	-	-	0.0	0.0
2	PI 595203	USA	0.5	0.5	0.3	0.0	1.0	0.0	1.0
3	PI 386019	Iran	0.7	0.7	0.6	2.0	0.0	0.0	-
4	PI 490377	Mali	1.3	1.3	1.0	1.0	-	0.0	3.0
5	PI 596662	South_Africa	1.5	1.5	1.1	0.0	2.0	1.0	3.0
6	PI 560016	Nigeria	1.8	1.8	1.1	1.0	3.0	0.0	3.0
7	PI 494528	Nigeria	2.0	2.0	1.3	2.0	2.0	2.0	2.0
8	PI 386025	Iran	2.3	2.3	1.6	3.0	3.0	2.0	1.0
9	PI 595201	USA	2.3	2.3	1.7	3.0	3.0	1.0	2.0
10	PI 494530	Nigeria	2.3	2.3	1.9	3.0	3.0	0.0	3.0
11	PI 485580	Botswana	2.5	2.5	1.4	1.0	4.0	2.0	3.0
12	PI 386016	Iran	2.5	2.5	1.5	2.0	3.0	2.0	3.0
13	PI 494529	Nigeria	2.8	2.8	2.2	3.0	3.0	2.0	3.0
14	PI 374216	Afghanistan	3.0	3.0	1.7	-	-	3.0	-
15	PI 386026	Iran	3.0	3.0	2.4	1.0	3.0	4.0	4.0
16	PI 386021	Iran	3.0	3.0	2.7	3.0	-	-	-
17	PI 482265	Zimbabwe	3.3	3.3	2.3	3.0	3.0	4.0	3.0
18	PI 485583	Botswana	3.3	3.3	2.3	3.0	4.0	2.0	4.0
19	PI 244018	South Africa	3.3	3.3	2.7	3.0	3.0	5.0	2.0
20	PI 386015	Iran	3.3	3.3	2.8	4.0	3.0	3.0	3.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
21	PI 482286	Zimbabwe	3.3	3.3	2.8	3.0	4.0	3.0	3.0
22	PI 482276	Zimbabwe	3.5	3.5	2.3	3.0	4.0	3.0	4.0
23	PI 596696	S. Africa	3.5	3.5	2.4	4.0	4.0	3.0	3.0
24	PI 596668	S. Africa	3.5	3.5	3.0	4.0	3.0	3.0	4.0
25	PI 596659	S. Africa	3.5	3.5	3.1	3.0	3.0	4.0	4.0
26	PI 596669	S. Africa	3.7	3.7	3.1	-	4.0	3.0	4.0
27	PI 596671	S. Africa	3.8	3.8	3.1	3.0	4.0	3.0	5.0
28	PI 386018	Iran	3.8	3.8	3.2	4.0	3.0	3.0	5.0
29	PI 244019	South_Africa	3.8	3.8	3.3	4.0	3.0	4.0	4.0
30	PI 482293	Zimbabwe	4.0	4.0	3.0	4.0	4.0	4.0	4.0
31	PI 559992	Nigeria	4.0	4.0	3.1	4.0	5.0	4.0	3.0
32	PI 485581	Botswana	4.0	4.0	3.2	4.0	5.0	4.0	3.0
33	PI 595202	USA	4.0	4.0	3.3	3.0	4.0	5.0	4.0
34	PI 542119	Botswana	4.0	4.0	3.3	3.0	4.0	4.0	5.0
35	PI 482309	Zimbabwe	4.3	4.3	3.4	5.0	5.0	4.0	3.0
36	PI 482342	Zimbabwe	4.3	4.3	3.5	4.0	4.0	5.0	4.0
37	PI 596666	S. Africa	4.3	4.3	3.5	4.0	5.0	4.0	4.0
38	PI 482315	Zimbabwe	4.3	4.3	3.7	5.0	5.0	4.0	3.0
39	PI 595200	USA	4.3	4.3	3.7	4.0	5.0	4.0	4.0
40	PI 271770	South_Africa	4.3	4.3	3.9	5.0	-	4.0	4.0
41	PI 532659	Zimbabwe	4.5	4.5	3.6	5.0	5.0	4.0	4.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
42	PI 549161	Chad	4.5	4.5	3.7	4.0	-	5.0	-
43	PI 512385	Spain	4.5	4.5	3.8	4.0	4.0	5.0	5.0
44	PI 500303	Zambia	4.5	4.5	3.8	5.0	5.0	4.0	4.0
45	PI 482308	Zimbabwe	4.5	4.5	3.8	5.0	5.0	3.0	5.0
46	PI 296334	South_Africa	4.8	4.8	4.0	4.0	4.0	5.0	6.0
47	PI 560015	Nigeria	4.8	4.8	4.0	5.0	6.0	4.0	4.0
48	PI 482273	Zimbabwe	4.8	4.8	4.1	4.0	5.0	5.0	5.0
49	PI 326516	Ghana	5.0	5.0	4.3	5.0	6.0	4.0	5.0
50	PI 537276	Pakistan	5.0	5.0	4.4	5.0	5.0	4.0	6.0
51	PI 271775	South_Africa	5.0	5.0	4.4	4.0	5.0	5.0	6.0
52	PI 560023	Nigeria	5.0	5.0	4.4	4.0	5.0	6.0	5.0
53	PI 220778	Afghanistan	5.0	5.0	4.5	-	5.0	-	5.0
54	PI 386024	Iran	5.0	5.0	4.6	5.0	5.0	5.0	5.0
55	PI 244017	S. Africa	5.3	5.3	4.4	5.0	5.0	5.0	6.0
56	PI 595219	USA	5.3	5.3	4.4	5.0	6.0	4.0	6.0
57	PI 482282	Zimbabwe	5.3	5.3	4.4	5.0	6.0	5.0	5.0
58	PI 189318	Nigeria	5.3	5.3	4.4	4.0	5.0	6.0	6.0
59	PI 596667	South_Africa	5.3	5.3	4.4	5.0	6.0	5.0	5.0
60	PI 388770	Morocco	5.3	5.3	4.5	5.0	6.0	5.0	5.0
61	PI 296341	South Africa	5.3	5.3	4.6	4.0	6.0	5.0	6.0
62	PI 482283	Zimbabwe	5.3	5.3	4.7	6.0	4.0	5.0	6.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
63	PI 482298	Zimbabwe	5.3	5.3	4.7	5.0	6.0	5.0	5.0
64	PI 482322	Zimbabwe	5.3	5.3	4.8	7.0	5.0	4.0	5.0
65	PI 174812	India	5.5	5.5	4.5	5.0	6.0	6.0	5.0
66	PI 482277	Zimbabwe	5.5	5.5	4.5	6.0	5.0	5.0	6.0
67	PI 296343	South_Africa	5.5	5.5	4.6	6.0	6.0	5.0	5.0
68	PI 500331	Zambia	5.5	5.5	4.7	5.0	6.0	5.0	6.0
69	PI 482311	Zimbabwe	5.5	5.5	4.8	5.0	5.0	6.0	6.0
70	PI 299378	South_Africa	5.5	5.5	4.8	6.0	6.0	5.0	5.0
71	PI 482299	Zimbabwe	5.5	5.5	4.8	5.0	5.0	6.0	6.0
72	PI 596665	South_Africa	5.5	5.5	4.8	6.0	5.0	6.0	5.0
73	PI 482302	Zimbabwe	5.5	5.5	4.8	6.0	6.0	5.0	5.0
74	PI 482316	Zimbabwe	5.5	5.5	4.8	6.0	5.0	6.0	5.0
75	PI 482324	Zimbabwe	5.5	5.5	4.9	5.0	6.0	5.0	6.0
76	PI 560012	Nigeria	5.5	5.5	5.0	5.0	5.0	6.0	6.0
77	PI 559999	Nigeria	5.8	5.8	4.7	5.0	6.0	6.0	6.0
78	PI 500355	Zambia	5.8	5.8	4.8	6.0	6.0	5.0	6.0
79	PI 482361	Zimbabwe	5.8	5.8	4.8	6.0	6.0	6.0	5.0
80	PI 482367	Zimbabwe	5.8	5.8	4.8	5.0	6.0	6.0	6.0
81	PI 512854	Spain	5.8	5.8	4.9	6.0	5.0	6.0	6.0
82	PI 560013	Nigeria	5.8	5.8	4.9	5.0	6.0	6.0	6.0
83	PI 299379	South_Africa	5.8	5.8	5.1	7.0	6.0	5.0	5.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
84	PI 222713	Iran	5.8	5.8	5.2	6.0	7.0	5.0	5.0
85	PI 482246	Zimbabwe	5.8	5.8	5.2	5.0	6.0	7.0	5.0
86	PI 482288	Zimbabwe	5.8	5.8	5.2	5.0	6.0	6.0	6.0
87	PI 296342	South_Africa	6.0	6.0	5.1	6.0	6.0	6.0	6.0
88	PI 500354	Zambia	6.0	6.0	5.1	6.0	6.0	7.0	5.0
89	PI 482307	Zimbabwe	6.0	6.0	5.3	7.0	6.0	6.0	5.0
90	PI 560009	Nigeria	6.0	6.0	5.3	5.0	7.0	7.0	5.0
91	PI 482301	Zimbabwe	6.0	6.0	5.4	6.0	6.0	7.0	5.0
92	PI 266027	Venezuela	6.0	6.0	5.4	5.0	.	6.0	7.0
93	PI 271769	South_Africa	6.0	6.0	5.5	6.0	5.0	6.0	7.0
94	PI 532738	Zaire	6.3	6.3	4.9	6.0	6.0	7.0	6.0
95	PI 482300	Zimbabwe	6.3	6.3	5.3	7.0	6.0	6.0	6.0
96	PI 186490	Nigeria	6.3	6.3	5.5	6.0	7.0	6.0	6.0
97	PI 249010	Nigeria	6.3	6.3	5.6	6.0	6.0	7.0	6.0
98	PI 171392	SouthAfrica	6.3	6.3	5.6	6.0	7.0	6.0	6.0
99	PI 255136	South_Africa	6.3	6.3	5.7	6.0	6.0	7.0	6.0
100	PI 379251	Yugoslavia	6.3	6.3	5.7	6.0	6.0	7.0	6.0
101	PI 500343	Zambia	6.3	6.3	5.8	5.0	6.0	7.0	7.0
102	PI 525081	Egypt	6.3	6.3	5.6	6.0	-	7.0	6.0
103	PI 482252	Zimbabwe	6.5	6.5	5.5	6.0	6.0	7.0	7.0
104	PI 189317	Nigeria	6.5	6.5	5.8	6.0	7.0	7.0	6.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
105	PI 482321	Zimbabwe	6.5	6.5	6.0	6.0	6.0	7.0	7.0
106	PI 271778	South_Africa	6.5	6.5	6.1	6.0	7.0	6.0	7.0
107	PI 214316	India	6.7	6.7	6.1	7.0	6.0	-	7.0
108	PI 357706	Yugoslavia	6.7	6.7	6.3	-	6.0	7.0	7.0
109	PI 482261	Zimbabwe	6.8	6.8	6.0	6.0	7.0	7.0	7.0
110	PI 379256	Yugoslavia	6.8	6.8	6.0	6.0	7.0	7.0	7.0
111	PI 271773	South_Africa	6.8	6.8	6.0	6.0	7.0	7.0	7.0
112	PI 482257	Zimbabwe	6.8	6.8	6.3	6.0	7.0	7.0	7.0
113	PI 482319	Zimbabwe	6.8	6.8	6.3	7.0	6.0	7.0	7.0
114	PI 505593	Zambia	6.8	6.8	6.3	7.0	6.0	7.0	7.0
115	PI 296339	South_Africa	7.0	7.0	5.8	7.0	7.0	7.0	7.0
116	PI 482331	Zimbabwe	7.0	7.0	6.0	8.0	6.0	7.0	7.0
117	PI 505604	Zambia	7.0	7.0	6.0	8.0	6.0	7.0	7.0
118	PI 559997	Nigeria	7.0	7.0	6.1	6.0	8.0	7.0	7.0
119	PI 532819	China	7.0	7.0	6.2	8.0	6.0	7.0	7.0
120	PI 500308	Zambia	7.0	7.0	6.2	7.0	8.0	6.0	7.0
121	PI 559996	Nigeria	7.0	7.0	6.3	8.0	6.0	7.0	7.0
122	PI 542122	Botswana	7.0	7.0	6.3	7.0	-	7.0	7.0
123	PI 632755	C. rehmii	7.0	7.0	6.3	7.0	7.0	-	-
124	PI 482303	Zimbabwe	7.0	7.0	6.3	7.0	7.0	7.0	7.0
125	PI 542120	Botswana	7.0	7.0	6.3	-	.	7.0	7.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
126	PI 482263	Zimbabwe	7.0	7.0	6.4	6.0	7.0	7.0	8.0
127	PI 459074	Botswana	7.0	7.0	6.5	6.0	7.0	7.0	8.0
128	PI 482262	Zimbabwe	7.0	7.0	6.5	7.0	6.0	8.0	7.0
129	PI 178874	Turkey	7.0	7.0	6.6	7.0	7.0	7.0	7.0
130	PI 186974	Ghana	7.0	7.0	6.6	7.0	7.0	7.0	7.0
131	PI 596653	South_Africa	7.3	7.3	6.2	8.0	7.0	7.0	7.0
132	PI 500334	Zambia	7.3	7.3	6.3	8.0	7.0	7.0	7.0
133	PI 169267	Turkey	7.3	7.3	6.3	7.0	8.0	7.0	7.0
134	PI 379243	Yugoslavia	7.3	7.3	6.3	7.0	7.0	8.0	7.0
135	PI 500306	Zambia	7.3	7.3	6.4	7.0	7.0	7.0	8.0
136	PI 482326	Zimbabwe	7.3	7.3	6.5	8.0	8.0	7.0	6.0
137	PI 482328	Zimbabwe	7.3	7.3	6.5	7.0	7.0	7.0	8.0
138	PI 532624	Zimbabwe	7.3	7.3	6.5	8.0	7.0	7.0	7.0
139	PI 560005	Nigeria	7.3	7.3	6.5	6.0	7.0	8.0	8.0
140	PI 271779	South_Africa	7.3	7.3	6.6	7.0	7.0	7.0	8.0
141	PI 505594	Zambia	7.3	7.3	6.6	7.0	7.0	8.0	7.0
142	PI 560014	Nigeria	7.3	7.3	6.6	6.0	7.0	8.0	8.0
143	PI 189316	Nigeria	7.3	7.3	6.6	7.0	7.0	8.0	7.0
144	PI 299563	South_Africa	7.3	7.3	6.6	6.0	7.0	8.0	8.0
145	PI 254744	Senegal	7.3	7.3	6.6	7.0	6.0	8.0	8.0
146	PI 357737	Yugoslavia	7.3	7.3	6.7	7.0	7.0	8.0	7.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
147	PI 482249	Zimbabwe	7.3	7.3	6.7	7.0	7.0	7.0	8.0
148	PI 277982	Turkey	7.3	7.3	6.7	8.0	7.0	7.0	7.0
149	PI 370425	Yugoslavia	7.3	7.3	6.7	7.0	7.0	8.0	7.0
150	PI 512376	Spain	7.3	7.3	6.7	7.0	8.0	7.0	7.0
151	PI 534586	Syria	7.3	7.3	6.7	8.0	7.0	7.0	7.0
152	PI 227204	Japan	7.3	7.3	6.7	8.0	7.0	7.0	7.0
153	PI 494531	Nigeria	7.3	7.3	6.8	7.0	7.0	8.0	7.0
154	PI 203551	USA	7.3	7.3	6.8	7.0	7.0	7.0	8.0
155	PI 222775	Iran	7.3	7.3	6.8	7.0	7.0	7.0	8.0
156	PI 255662	Afghanistan	7.3	7.3	6.8	7.0	7.0	8.0	7.0
157	PI 227202	Japan	7.3	7.3	6.8	8.0	7.0	7.0	7.0
158	PI 255139	S. Africa	7.3	7.3	6.8	8.0	7.0	7.0	7.0
159	PI 219691	Pakistan	7.3	7.3	6.8	7.0	7.0	8.0	7.0
160	PI 526232	Zimbabwe	7.3	7.3	6.9	7.0	7.0	7.0	8.0
161	PI 208740	Cuba	7.3	7.3	7.0	8.0	7.0	7.0	7.0
162	PI 381703	India	7.3	7.3	7.0	7.0	7.0	7.0	8.0
163	PI 183123	India	7.3	7.3	7.0	-	7.0	7.0	8.0
164	PI 271132	Tunisia	7.3	7.3	7.0	7.0	8.0	7.0	-
165	PI 482335	Zimbabwe	7.5	7.5	6.1	8.0	8.0	7.0	7.0
166	PI 560010	Nigeria	7.5	7.5	6.2	7.0	7.0	8.0	8.0
167	PI 482355	Zimbabwe	7.5	7.5	6.3	8.0	7.0	8.0	7.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
168	PI 186975	Ghana	7.5	7.5	6.4	8.0	8.0	8.0	6.0
169	PI 560017	Nigeria	7.5	7.5	6.5	6.0	7.0	8.0	9.0
170	PI 307608	Nigeria	7.5	7.5	6.5	8.0	-	7.0	-
171	PI 612466	Korea S.	7.5	7.5	6.5	7.0	7.0	8.0	8.0
172	PI 189225	Zaire	7.5	7.5	6.6	7.0	7.0	8.0	8.0
173	PI 532726	Zimbabwe	7.5	7.5	6.6	8.0	7.0	8.0	7.0
174	PI 255137	South_Africa	7.5	7.5	6.6	7.0	8.0	8.0	7.0
175	PI 482338	Zimbabwe	7.5	7.5	6.6	8.0	8.0	7.0	7.0
176	PI 505592	Zambia	7.5	7.5	6.7	8.0	7.0	7.0	8.0
177	PI 482336	Zimbabwe	7.5	7.5	6.7	7.0	-	8.0	-
178	PI 482380	Zimbabwe	7.5	7.5	6.7	7.0	7.0	8.0	8.0
179	PI 500350	Zambia	7.5	7.5	6.7	8.0	7.0	7.0	8.0
180	PI 560003	Nigeria	7.5	7.5	6.7	7.0	7.0	8.0	8.0
181	PI 248774	Namibia	7.5	7.5	6.7	8.0	7.0	7.0	8.0
182	PI 500324	Zambia	7.5	7.5	6.7	8.0	7.0	7.0	8.0
183	PI 512399	Spain	7.5	7.5	6.7	8.0	8.0	7.0	7.0
184	PI 225557	Zimbabwe	7.5	7.5	6.7	8.0	7.0	7.0	8.0
185	PI 482347	Zimbabwe	7.5	7.5	6.7	7.0	8.0	7.0	8.0
186	PI 593346	China	7.5	7.5	6.7	6.0	7.0	8.0	9.0
187	PI 185636	Ghana	7.5	7.5	6.8	7.0	7.0	8.0	8.0
188	PI 459075	Botswana	7.5	7.5	6.8	7.0	7.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
189	PI 490386	Mali	7.5	7.5	6.8	8.0	8.0	7.0	7.0
190	PI 482272	Zimbabwe	7.5	7.5	6.8	7.0	9.0	7.0	7.0
191	PI 482294	Zimbabwe	7.5	7.5	6.8	7.0	7.0	8.0	8.0
192	PI 482318	Zimbabwe	7.5	7.5	6.8	9.0	6.0	7.0	8.0
193	PI 532666	Zimbabwe	7.5	7.5	6.8	7.0	7.0	8.0	8.0
194	PI 535948	Cameroon	7.5	7.5	6.8	8.0	7.0	8.0	7.0
195	PI 178876	Turkey	7.5	7.5	6.8	7.0	8.0	8.0	7.0
196	PI 457916	Brazil	7.5	7.5	6.8	7.0	7.0	7.0	9.0
197	PI 186489	Nigeria	7.5	7.5	6.8	8.0	8.0	7.0	7.0
198	PI 593384	China	7.5	7.5	6.8	8.0	8.0	7.0	7.0
199	PI 217939	Pakistan	7.5	7.5	6.8	8.0	8.0	7.0	7.0
200	PI 293766	Soviet Union	7.5	7.5	6.8	8.0	8.0	7.0	7.0
201	PI 482374	Zimbabwe	7.5	7.5	6.8	8.0	8.0	7.0	7.0
202	PI 184800	Nigeria	7.5	7.5	6.8	7.0	7.0	8.0	8.0
203	PI 368528	Yugoslavia	7.5	7.5	6.8	8.0	7.0	7.0	8.0
204	PI 172790	Turkey	7.5	7.5	6.8	7.0	7.0	8.0	8.0
205	PI 271984	Somalia	7.5	7.5	6.8	7.0	7.0	7.0	9.0
206	PI 482339	Zimbabwe	7.5	7.5	6.8	7.0	8.0	7.0	8.0
207	PI 247398	Greece	7.5	7.5	6.9	7.0	8.0	7.0	8.0
208	PI 249009	Nigeria	7.5	7.5	6.9	7.0	7.0	8.0	8.0
209	PI 270550	Ghana	7.5	7.5	6.9	8.0	7.0	7.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
210	PI 179240	Turkey	7.5	7.5	6.9	7.0	7.0	8.0	8.0
211	PI 254743	Senegal	7.5	7.5	6.9	8.0	7.0	8.0	7.0
212	PI 270522	Israel	7.5	7.5	6.9	8.0	8.0	7.0	7.0
213	PI 278034	Turkey	7.5	7.5	6.9	8.0	7.0	7.0	8.0
214	PI 593340	China	7.5	7.5	6.9	8.0	7.0	7.0	8.0
215	PI 593341	China	7.5	7.5	6.9	7.0	7.0	8.0	8.0
216	PI 536463	Maldives	7.5	7.5	6.9	7.0	9.0	7.0	7.0
217	PI 174098	Turkey	7.5	7.5	7.0	7.0	7.0	8.0	8.0
218	PI 183300	India	7.5	7.5	7.0	8.0	7.0	7.0	8.0
219	PI 173669	Turkey	7.5	7.5	7.0	8.0	8.0	7.0	7.0
220	PI 177325	Turkey	7.5	7.5	7.0	7.0	7.0	8.0	8.0
221	PI 222715	Iran	7.5	7.5	7.0	8.0	8.0	7.0	7.0
222	PI 176915	Turkey	7.5	7.5	7.0	8.0	7.0	8.0	7.0
223	PI 179660	India	7.5	7.5	7.0	7.0	8.0	8.0	7.0
224	PI 183022	India	7.5	7.5	7.0	7.0	-	8.0	-
225	PI 277983	Turkey	7.5	7.5	7.0	7.0	-	-	8.0
226	PI 357718	Yugoslavia	7.5	7.5	7.0	7.0	7.0	7.0	9.0
227	PI 169273	Turkey	7.5	7.5	7.1	8.0	7.0	7.0	8.0
228	PI 222184	Afghanistan	7.5	7.5	7.1	7.0	8.0	7.0	8.0
229	PI 183673	Turkey	7.5	7.5	7.1	8.0	8.0	7.0	7.0
230	PI 179661	India	7.5	7.5	7.1	7.0	8.0	8.0	7.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
231	PI 180427	India	7.5	7.5	7.1	7.0	7.0	7.0	9.0
232	PI 490378	Mali	7.7	7.7	6.6	8.0	9.0	6.0	-
233	PI 494532	Nigeria	7.7	7.7	6.7	7.0	8.0	8.0	-
234	PI 173670	Turkey	7.7	7.7	6.8	7.0	-	8.0	8.0
235	PI 583809	USA	7.7	7.7	6.8	9.0	-	7.0	7.0
236	PI 306367	Angola	7.7	7.7	6.9	7.0	7.0	-	9.0
237	PI 247399	Greece	7.7	7.7	6.9	7.0	-	8.0	8.0
238	PI 179239	Turkey	7.7	7.7	6.9	8.0	8.0	-	7.0
239	PI 207471	Afghanistan	7.7	7.7	7.0	8.0	7.0	8.0	-
240	PI 295842	South Africa	7.7	7.7	7.0	-	8.0	8.0	7.0
241	PI 183125	India	7.7	7.7	7.0	8.0	7.0	-	8.0
242	PI 183023	India	7.7	7.7	7.1	-	8.0	7.0	8.0
243	PI 500327	Zambia	7.8	7.8	6.5	8.0	8.0	8.0	7.0
244	PI 560011	Nigeria	7.8	7.8	6.5	6.0	8.0	8.0	9.0
245	PI 306782	Nigeria	7.8	7.8	6.5	6.0	9.0	9.0	7.0
246	PI 482275	Zimbabwe	7.8	7.8	6.6	8.0	7.0	8.0	8.0
247	PI 482280	Zimbabwe	7.8	7.8	6.6	8.0	8.0	7.0	8.0
248	PI 596656	South_Africa	7.8	7.8	6.6	8.0	7.0	8.0	8.0
249	PI 532723	Zimbabwe	7.8	7.8	6.6	7.0	8.0	8.0	8.0
250	PI 532664	Zimbabwe	7.8	7.8	6.7	7.0	8.0	8.0	8.0
251	PI 542114	Botswana	7.8	7.8	6.7	8.0	8.0	7.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
252	PI 542116	Botswana	7.8	7.8	6.7	7.0	7.0	8.0	9.0
253	PI 482274	Zimbabwe	7.8	7.8	6.8	7.0	7.0	8.0	9.0
254	PI 319237	Japan	7.8	7.8	6.8	8.0	8.0	7.0	8.0
255	PI 500323	Zambia	7.8	7.8	6.8	8.0	8.0	7.0	8.0
256	PI 296335	South_Africa	7.8	7.8	6.8	7.0	6.0	9.0	9.0
257	PI 482341	Zimbabwe	7.8	7.8	6.8	6.0	7.0	9.0	9.0
258	PI 482378	Zimbabwe	7.8	7.8	6.8	8.0	8.0	7.0	8.0
259	PI 560019	Nigeria	7.8	7.8	6.8	7.0	7.0	8.0	9.0
260	PI 629103	USA	7.8	7.8	6.8	8.0	8.0	7.0	8.0
261	PI 200732	El Salvador	7.8	7.8	6.8	8.0	7.0	8.0	8.0
262	PI 532730	Zimbabwe	7.8	7.8	6.8	8.0	8.0	7.0	8.0
263	PI 560002	Nigeria	7.8	7.8	6.8	8.0	7.0	8.0	8.0
264	PI 482333	Zimbabwe	7.8	7.8	6.8	8.0	7.0	8.0	8.0
265	PI 500338	Zambia	7.8	7.8	6.8	7.0	8.0	8.0	8.0
266	PI 211852	Iran	7.8	7.8	6.8	8.0	8.0	7.0	8.0
267	PI 381713	India	7.8	7.8	6.8	7.0	8.0	8.0	8.0
268	PI 482264	Zimbabwe	7.8	7.8	6.8	7.0	8.0	8.0	8.0
269	PI 500311	Zambia	7.8	7.8	6.8	8.0	7.0	8.0	8.0
270	PI 500340	Zambia	7.8	7.8	6.8	8.0	8.0	7.0	8.0
271	PI 536446	Maldives	7.8	7.8	6.8	7.0	8.0	8.0	8.0
272	PI 500329	Zambia	7.8	7.8	6.8	7.0	8.0	9.0	7.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
273	PI 525095	Egypt	7.8	7.8	6.8	8.0	7.0	8.0	8.0
274	PI 482256	Zimbabwe	7.8	7.8	6.8	8.0	8.0	7.0	8.0
275	PI 195927	Ethiopia	7.8	7.8	6.8	8.0	7.0	8.0	8.0
276	PI 276444	Jordan	7.8	7.8	6.8	9.0	7.0	7.0	8.0
277	PI 482377	Zimbabwe	7.8	7.8	6.8	8.0	7.0	7.0	9.0
278	PI 526238	Zimbabwe	7.8	7.8	6.9	7.0	8.0	8.0	8.0
279	PI 254622	Sudan	7.8	7.8	6.9	8.0	8.0	7.0	8.0
280	PI 379257	Yugoslavia	7.8	7.8	6.9	7.0	8.0	8.0	8.0
281	PI 482312	Zimbabwe	7.8	7.8	6.9	8.0	7.0	8.0	8.0
282	PI 560004	Nigeria	7.8	7.8	6.9	7.0	7.0	8.0	9.0
283	PI 525099	Italy	7.8	7.8	6.9	8.0	8.0	7.0	8.0
284	PI 270140	India	7.8	7.8	6.9	8.0	7.0	8.0	8.0
285	PI 482365	Zimbabwe	7.8	7.8	6.9	7.0	7.0	8.0	9.0
286	PI 392291	Kenya	7.8	7.8	6.9	9.0	6.0	8.0	8.0
287	PI 482250	Zimbabwe	7.8	7.8	6.9	7.0	7.0	8.0	9.0
288	PI 482357	Zimbabwe	7.8	7.8	6.9	6.0	8.0	8.0	9.0
289	PI 482375	Zimbabwe	7.8	7.8	6.9	7.0	8.0	9.0	7.0
290	PI 505595	Zambia	7.8	7.8	6.9	8.0	7.0	7.0	9.0
291	PI 534595	Syria	7.8	7.8	6.9	8.0	8.0	7.0	8.0
292	PI 536450	Maldives	7.8	7.8	6.9	9.0	8.0	7.0	7.0
293	PI 505590	Zambia	7.8	7.8	7.0	8.0	7.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
294	Grif 5600	India	7.8	7.8	7.0	7.0	8.0	8.0	8.0
295	PI 172786	Turkey	7.8	7.8	7.0	8.0	8.0	8.0	7.0
296	PI 180278	India	7.8	7.8	7.0	8.0	8.0	7.0	8.0
297	PI 246559	Senegal	7.8	7.8	7.0	8.0	8.0	8.0	7.0
298	PI 381715	India	7.8	7.8	7.0	8.0	8.0	8.0	7.0
299	PI 381716	India	7.8	7.8	7.0	8.0	7.0	7.0	9.0
300	Grif 1729	China	7.8	7.8	7.0	8.0	8.0	8.0	7.0
301	PI 169296	Turkey	7.8	7.8	7.0	8.0	8.0	7.0	8.0
302	PI 174104	Turkey	7.8	7.8	7.0	8.0	8.0	7.0	8.0
303	PI 204689	Turkey	7.8	7.8	7.0	8.0	7.0	8.0	8.0
304	PI 482253	Zimbabwe	7.8	7.8	7.0	7.0	8.0	8.0	8.0
305	PI 482271	Zimbabwe	7.8	7.8	7.0	8.0	7.0	9.0	7.0
306	PI 482360	Zimbabwe	7.8	7.8	7.0	7.0	8.0	8.0	8.0
307	PI 596675	S. Africa	7.8	7.8	7.0	7.0	8.0	8.0	8.0
308	PI 172797	Turkey	7.8	7.8	7.0	8.0	8.0	7.0	8.0
309	PI 505586	Zambia	7.8	7.8	7.0	7.0	7.0	8.0	9.0
310	PI 278038	Turkey	7.8	7.8	7.0	9.0	7.0	7.0	8.0
311	PI 179881	India	7.8	7.8	7.0	8.0	9.0	7.0	7.0
312	PI 229686	Iran	7.8	7.8	7.1	8.0	7.0	8.0	8.0
313	PI 254736	Senegal	7.8	7.8	7.1	8.0	7.0	8.0	8.0
314	PI 274794	Pakistan	7.8	7.8	7.1	8.0	7.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
315	PI 278025	Turkey	7.8	7.8	7.1	8.0	8.0	7.0	8.0
316	PI 482304	Zimbabwe	7.8	7.8	7.1	8.0	7.0	8.0	8.0
317	PI 508446	Korea, South	7.8	7.8	7.1	8.0	8.0	8.0	7.0
318	PI 176913	Turkey	7.8	7.8	7.1	8.0	8.0	8.0	7.0
319	PI 177326	Turkey	7.8	7.8	7.1	8.0	8.0	8.0	7.0
320	PI 200733	Guatemala	7.8	7.8	7.1	8.0	7.0	8.0	8.0
321	PI 249008	Nigeria	7.8	7.8	7.1	7.0	8.0	8.0	8.0
322	PI 174109	Turkey	7.8	7.8	7.1	8.0	7.0	7.0	9.0
323	PI 357705	Yugoslavia	7.8	7.8	7.1	7.0	8.0	9.0	7.0
324	PI 177324	Turkey	7.8	7.8	7.1	8.0	8.0	8.0	7.0
325	PI 179878	India	7.8	7.8	7.1	8.0	7.0	7.0	9.0
326	PI 500307	Zambia	7.8	7.8	7.1	8.0	8.0	7.0	8.0
327	PI 381698	India	7.8	7.8	7.1	6.0	7.0	9.0	9.0
328	PI 172792	Turkey	7.8	7.8	7.2	8.0	7.0	8.0	8.0
329	PI 179232	Turkey	7.8	7.8	7.2	8.0	8.0	7.0	8.0
330	PI 207473	Afghanistan	7.8	7.8	7.2	8.0	7.0	8.0	8.0
331	PI 227205	Japan	7.8	7.8	7.2	8.0	8.0	7.0	8.0
332	PI 379245	Yugoslavia	7.8	7.8	7.2	8.0	7.0	8.0	8.0
333	PI 534596	Syria	7.8	7.8	7.2	7.0	7.0	8.0	9.0
334	PI 176498	Turkey	7.8	7.8	7.2	8.0	8.0	8.0	7.0
335	PI 269465	Pakistan	7.8	7.8	7.2	8.0	7.0	7.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
336	PI 176921	Turkey	7.8	7.8	7.3	8.0	8.0	7.0	8.0
337	PI 180426	India	7.8	7.8	7.3	9.0	8.0	7.0	7.0
338	PI 254741	Senegal	7.8	7.8	7.3	7.0	8.0	8.0	8.0
339	PI 178871	Turkey	7.8	7.8	7.4	7.0	7.0	8.0	9.0
340	PI 169274	Turkey	7.8	8.0	7.2	9.0	7.0	7.0	8.0
341	Charlee	USA	8.0	8.0	6.3	-	-	8.0	-
342	PI 532669	Zimbabwe	8.0	8.0	6.3	-	8.0	-	-
343	PI 542123	Botswana	8.0	8.0	6.3	8.0	-	-	-
344	PI 596670	S. Africa	8.0	8.0	6.5	8.0	8.0	8.0	8.0
345	PI 485579	Zimbabwe	8.0	8.0	6.7	8.0	-	8.0	-
346	Louisiana Sweet	USA	8.0	8.0	6.7	-	8.0	-	-
347	PI 482269	Zimbabwe	8.0	8.0	6.7	8.0	8.0	8.0	8.0
348	PI 542616	Algeria	8.0	8.0	6.7	8.0	-	-	-
349	PI 560008	Nigeria	8.0	8.0	6.7	8.0	8.0	8.0	8.0
350	PI 490382	Mali	8.0	8.0	6.8	8.0	8.0	8.0	8.0
351	PI 532814	China	8.0	8.0	6.8	9.0	8.0	8.0	7.0
352	PI 560020	Nigeria	8.0	8.0	6.8	8.0	8.0	8.0	8.0
353	PI 229749	Iran	8.0	8.0	6.8	8.0	8.0	8.0	8.0
354	PI 482258	Zimbabwe	8.0	8.0	6.8	8.0	8.0	8.0	8.0
355	PI 482279	Zimbabwe	8.0	8.0	6.8	8.0	8.0	7.0	9.0
356	PI 482306	Zimbabwe	8.0	8.0	6.8	8.0	8.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
357	PI 482334	Zimbabwe	8.0	8.0	6.8	8.0	8.0	-	8.0
358	PI 500313	Zambia	8.0	8.0	6.8	8.0	8.0	8.0	8.0
359	PI 537269	Pakistan	8.0	8.0	6.8	8.0	7.0	8.0	9.0
360	PI 593361	China	8.0	8.0	6.8	8.0	8.0	8.0	8.0
361	Big Crimson	USA	8.0	8.0	6.8	8.0	8.0	-	-
362	Blacklee	USA	8.0	8.0	6.8	7.0	8.0	9.0	8.0
363	PI 234603	USA	8.0	8.0	6.8	8.0	8.0	8.0	8.0
364	PI 596658	S. Africa	8.0	8.0	6.8	8.0	-	-	8.0
365	PI 526236	Zimbabwe	8.0	8.0	6.8	8.0	7.0	9.0	8.0
366	PI 248178	Zaire	8.0	8.0	6.9	8.0	8.0	-	8.0
367	PI 512402	Spain	8.0	8.0	6.9	8.0	9.0	7.0	-
368	PI 482344	Zimbabwe	8.0	8.0	6.9	9.0	8.0	8.0	7.0
369	PI 500344	Zambia	8.0	8.0	6.9	7.0	8.0	9.0	8.0
370	PI 537267	Pakistan	8.0	8.0	6.9	8.0	7.0	9.0	8.0
371	PI 476324	Soviet Union	8.0	8.0	6.9	9.0	7.0	8.0	8.0
372	PI 266025	Venezuela	8.0	8.0	6.9	8.0	8.0	8.0	8.0
373	PI 270562	S. Africa	8.0	8.0	6.9	8.0	8.0	8.0	8.0
374	PI 319212	Egypt	8.0	8.0	6.9	8.0	8.0	7.0	9.0
375	PI 379238	Yugoslavia	8.0	8.0	6.9	8.0	8.0	8.0	8.0
376	PI 430615	China	8.0	8.0	6.9	8.0	8.0	8.0	8.0
377	PI 487476	Israel	8.0	8.0	6.9	8.0	8.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
378	PI 532816	China	8.0	8.0	6.9	8.0	8.0	8.0	8.0
379	PI 559995	Nigeria	8.0	8.0	6.9	8.0	8.0	8.0	8.0
380	PI 482296	Zimbabwe	8.0	8.0	6.9	7.0	8.0	8.0	9.0
381	PI 542121	Botswana	8.0	8.0	6.9	7.0	8.0	8.0	9.0
382	PI 593344	China	8.0	8.0	7.0	8.0	7.0	8.0	9.0
383	PI 512379	Spain	8.0	8.0	7.0	7.0	8.0	8.0	9.0
384	PI 345544	Ukraine	8.0	8.0	7.0	8.0	8.0	8.0	8.0
385	Giza	USA	8.0	8.0	7.0	8.0	-	7.0	9.0
386	Hopi Red Flesh	USA	8.0	8.0	7.0	8.0	-	8.0	8.0
387	PI 169257	Turkey	8.0	8.0	7.0	8.0	8.0	8.0	8.0
388	PI 169282	Turkey	8.0	8.0	7.0	8.0	8.0	8.0	8.0
389	PI 175665	Turkey	8.0	8.0	7.0	-	8.0	8.0	8.0
390	PI 177329	Turkey	8.0	8.0	7.0	8.0	8.0	8.0	8.0
391	PI 212094	Afghanistan	8.0	8.0	7.0	8.0	8.0	8.0	8.0
392	PI 254431	Lebanon	8.0	8.0	7.0	8.0	8.0	8.0	-
393	PI 271776	S. Africa	8.0	8.0	7.0	8.0	8.0	8.0	8.0
394	PI 278009	Turkey	8.0	8.0	7.0	8.0	8.0	8.0	8.0
395	PI 278045	Turkey	8.0	8.0	7.0	8.0	-	8.0	8.0
396	PI 288316	India	8.0	8.0	7.0	-	8.0	-	8.0
397	PI 306364	Gabon	8.0	8.0	7.0	8.0	8.0	8.0	8.0
398	PI 357674	Yugoslavia	8.0	8.0	7.0	8.0	8.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
399	PI 357744	Yugoslavia	8.0	8.0	7.0	8.0	8.0	8.0	8.0
400	PI 370422	Yugoslavia	8.0	8.0	7.0	8.0	8.0	8.0	8.0
401	PI 379246	Yugoslavia	8.0	8.0	7.0	8.0	8.0	8.0	8.0
402	PI 435990	China	8.0	8.0	7.0	8.0	8.0	8.0	8.0
403	PI 482248	Zimbabwe	8.0	8.0	7.0	8.0	8.0	8.0	8.0
404	PI 482281	Zimbabwe	8.0	8.0	7.0	8.0	8.0	8.0	8.0
405	PI 482327	Zimbabwe	8.0	8.0	7.0	8.0	8.0	8.0	8.0
406	PI 482381	Zimbabwe	8.0	8.0	7.0	8.0	8.0	8.0	8.0
407	PI 500304	Zambia	8.0	8.0	7.0	-	8.0	8.0	8.0
408	PI 500319	Zambia	8.0	8.0	7.0	8.0	7.0	9.0	8.0
409	PI 500328	Zambia	8.0	8.0	7.0	8.0	8.0	8.0	8.0
410	PI 500336	Zambia	8.0	8.0	7.0	9.0	8.0	7.0	8.0
411	PI 505587	Zambia	8.0	8.0	7.0	8.0	8.0	8.0	8.0
412	PI 512401	Spain	8.0	8.0	7.0	.	8.0	-	8.0
413	PI 526234	Zimbabwe	8.0	8.0	7.0	8.0	8.0	8.0	8.0
414	PI 537266	Pakistan	8.0	8.0	7.0	8.0	8.0	8.0	8.0
415	PI 593365	China	8.0	8.0	7.0	8.0	8.0	-	8.0
416	PI 593385	China	8.0	8.0	7.0	8.0	8.0	9.0	7.0
417	PI 596687	S. Africa	8.0	8.0	7.0	-	-	8.0	-
418	PI 600903	USA	8.0	8.0	7.0	8.0	8.0	8.0	8.0
419	PI 612468	Korea	8.0	8.0	7.0	8.0	8.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
420	Red'N'Sweet	USA	8.0	8.0	7.0	8.0	-	-	8.0
421	PI 164977	Turkey	8.0	8.0	7.0	8.0	8.0	8.0	8.0
422	PI 169269	Turkey	8.0	8.0	7.0	8.0	8.0	7.0	9.0
423	PI 183218	Egypt	8.0	8.0	7.0	8.0	8.0	8.0	8.0
424	PI 193963	Ethiopia	8.0	8.0	7.0	8.0	8.0	8.0	8.0
425	PI 233556	Japan	8.0	8.0	7.0	8.0	7.0	8.0	9.0
426	PI 266015	Venezuela	8.0	8.0	7.0	8.0	8.0	8.0	8.0
427	PI 432337	Cyprus	8.0	8.0	7.0	7.0	8.0	8.0	9.0
428	PI 442826	Brazil	8.0	8.0	7.0	8.0	8.0	8.0	8.0
429	PI 482268	Zimbabwe	8.0	8.0	7.0	8.0	8.0	8.0	8.0
430	PI 512377	Spain	8.0	8.0	7.0	7.0	8.0	9.0	8.0
431	PI 525083	Egypt	8.0	8.0	7.0	7.0	8.0	8.0	9.0
432	PI 537468	Spain	8.0	8.0	7.0	8.0	7.0	8.0	9.0
433	PI 164247	Liberia	8.0	8.0	7.0	8.0	8.0	-	8.0
434	PI 274035	S. Africa	8.0	8.0	7.0	-	8.0	8.0	8.0
435	PI 500335	Zambia	8.0	8.0	7.0	7.0	8.0	9.0	8.0
436	PI 512349	Spain	8.0	8.0	7.0	8.0	8.0	8.0	8.0
437	PI 549163	Chad	8.0	8.0	7.0	7.0	8.0	8.0	9.0
438	PI 169259	Turkey	8.0	8.0	7.1	8.0	8.0	8.0	8.0
439	PI 192937	China	8.0	8.0	7.1	8.0	8.0	8.0	8.0
440	PI 278051	Turkey	8.0	8.0	7.1	9.0	9.0	7.0	7.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
441	PI 319236	Japan	8.0	8.0	7.1	8.0	8.0	8.0	8.0
442	PI 357661	Yugoslavia	8.0	8.0	7.1	8.0	7.0	9.0	8.0
443	PI 525090	Egypt	8.0	8.0	7.1	8.0	8.0	8.0	8.0
444	PI 534585	Syria	8.0	8.0	7.1	8.0	8.0	8.0	8.0
445	PI 593375	China	8.0	8.0	7.1	8.0	8.0	8.0	8.0
446	PI 612464	Korea	8.0	8.0	7.1	8.0	8.0	8.0	8.0
447	Gri 12336	China	8.0	8.0	7.1	8.0	8.0	8.0	8.0
448	PI 163572	Guatemala	8.0	8.0	7.1	8.0	8.0	8.0	8.0
449	PI 169240	Turkey	8.0	8.0	7.1	9.0	7.0	8.0	8.0
450	PI 169248	Turkey	8.0	8.0	7.1	8.0	8.0	8.0	8.0
451	PI 169262	Turkey	8.0	8.0	7.1	8.0	8.0	8.0	8.0
452	PI 171585	Turkey	8.0	8.0	7.1	8.0	8.0	8.0	8.0
453	PI 174108	Turkey	8.0	8.0	7.1	8.0	8.0	8.0	8.0
454	PI 176918	Turkey	8.0	8.0	7.1	8.0	8.0	8.0	8.0
455	PI 181936	Syria	8.0	8.0	7.1	8.0	8.0	8.0	8.0
456	PI 212289	Afghanistan	8.0	8.0	7.1	8.0	8.0	8.0	8.0
457	PI 219906	Afghanistan	8.0	8.0	7.1	8.0	8.0	8.0	8.0
458	PI 260733	Sudan	8.0	8.0	7.1	8.0	8.0	8.0	8.0
459	PI 271751	Ghana	8.0	8.0	7.1	8.0	8.0	8.0	8.0
460	PI 296332	S. Africa	8.0	8.0	7.1	8.0	8.0	8.0	8.0
461	PI 357660	Yugoslavia	8.0	8.0	7.1	8.0	8.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
462	PI 379233	Yugoslavia	8.0	8.0	7.1	8.0	8.0	8.0	8.0
463	PI 381736	India	8.0	8.0	7.1	8.0	8.0	8.0	8.0
464	PI 385963	Kenya	8.0	8.0	7.1	8.0	8.0	8.0	8.0
465	PI 388021	India	8.0	8.0	7.1	7.0	8.0	9.0	8.0
466	PI 482353	Zimbabwe	8.0	8.0	7.1	8.0	7.0	8.0	9.0
467	PI 512373	Spain	8.0	8.0	7.1	8.0	8.0	8.0	8.0
468	PI 518611	SovieUnion	8.0	8.0	7.1	8.0	8.0	8.0	8.0
469	PI 535947	Cameroon	8.0	8.0	7.1	8.0	8.0	8.0	8.0
470	PI 593352	China	8.0	8.0	7.1	8.0	8.0	8.0	8.0
471	PI 180277	India	8.0	8.0	7.1	9.0	8.0	7.0	8.0
472	PI 227203	Japan	8.0	8.0	7.1	8.0	7.0	9.0	8.0
473	PI 278046	Turkey	8.0	8.0	7.1	8.0	8.0	8.0	8.0
474	PI 482359	Zimbabwe	8.0	8.0	7.1	8.0	8.0	7.0	9.0
475	PI 532811	China	8.0	8.0	7.1	7.0	8.0	8.0	9.0
476	PI 593387	China	8.0	8.0	7.1	8.0	8.0	8.0	8.0
477	PI 277979	Turkey	8.0	8.0	7.1	8.0	9.0	8.0	7.0
478	PI 177327	Turkey	8.0	8.0	7.1	-	8.0	8.0	8.0
479	PI 470247	Indonesia	8.0	8.0	7.1	8.0	8.0	-	8.0
480	PI 482292	Zimbabwe	8.0	8.0	7.1	7.0	9.0	-	8.0
481	PI 482330	Zimbabwe	8.0	8.0	7.1	8.0	-	8.0	8.0
482	Grif 5598	India	8.0	8.0	7.2	8.0	8.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
483	PI 542617	Algeria	8.0	8.0	7.2	8.0	8.0	8.0	8.0
484	PI 270549	Ghana	8.0	8.0	7.2	8.0	8.0	8.0	8.0
485	PI 368515	Yugoslavia	8.0	8.0	7.2	8.0	8.0	8.0	8.0
486	PI 164248	Liberia	8.0	8.0	7.2	8.0	8.0	8.0	8.0
487	PI 169289	Turkey	8.0	8.0	7.2	8.0	8.0	8.0	8.0
488	PI 175657	Turkey	8.0	8.0	7.2	8.0	8.0	8.0	8.0
489	PI 175663	Turkey	8.0	8.0	7.2	8.0	8.0	8.0	8.0
490	PI 211013	Afghanistan	8.0	8.0	7.2	8.0	8.0	8.0	8.0
491	PI 211915	Iran	8.0	8.0	7.2	8.0	8.0	7.0	9.0
492	PI 212209	Greece	8.0	8.0	7.2	8.0	8.0	8.0	8.0
493	PI 217937	Pakistan	8.0	8.0	7.2	8.0	8.0	8.0	8.0
494	PI 219907	Afghanistan	8.0	8.0	7.2	8.0	8.0	8.0	8.0
495	PI 254737	Senegal	8.0	8.0	7.2	8.0	8.0	8.0	8.0
496	PI 254740	Senegal	8.0	8.0	7.2	8.0	8.0	8.0	8.0
497	PI 271777	S. Africa	8.0	8.0	7.2	8.0	8.0	8.0	8.0
498	PI 368496	Yugoslavia	8.0	8.0	7.2	8.0	8.0	8.0	8.0
499	PI 368512	Yugoslavia	8.0	8.0	7.2	8.0	8.0	8.0	8.0
500	PI 482323	Zimbabwe	8.0	8.0	7.2	8.0	7.0	8.0	9.0
501	PI 512360	Spain	8.0	8.0	7.2	8.0	8.0	8.0	8.0
502	PI 178877	Turkey	8.0	8.0	7.2	8.0	8.0	8.0	8.0
503	PI 192938	China	8.0	8.0	7.2	8.0	8.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
504	PI 269676	Belize	8.0	8.0	7.2	8.0	8.0	8.0	8.0
505	PI 269677	Belize	8.0	8.0	7.2	8.0	9.0	8.0	7.0
506	PI 458739	Paraguay	8.0	8.0	7.2	8.0	8.0	7.0	9.0
507	PI 593389	China	8.0	8.0	7.2	7.0	9.0	8.0	8.0
508	PI 176914	Turkey	8.0	8.0	7.2	7.0	8.0	9.0	8.0
509	PI 482371	Zimbabwe	8.0	8.0	7.2	8.0	8.0	8.0	8.0
510	PI 270563	S. Africa	8.0	8.0	7.2	8.0	7.0	8.0	9.0
511	PI 176496	Turkey	8.0	8.0	7.2	8.0	-	8.0	8.0
512	PI 181868	Syria	8.0	8.0	7.2	-	8.0	8.0	8.0
513	PI 357709	Yugoslavia	8.0	8.0	7.3	8.0	8.0	8.0	8.0
514	PI 181937	Syria	8.0	8.0	7.3	8.0	8.0	8.0	8.0
515	PI 270551	Ghana	8.0	8.0	7.3	8.0	8.0	8.0	8.0
516	PI 357680	Yugoslavia	8.0	8.0	7.3	8.0	8.0	8.0	8.0
517	PI 534588	Syria	8.0	8.0	7.3	8.0	8.0	8.0	8.0
518	PI 164804	India	8.0	8.0	7.3	7.0	8.0	8.0	9.0
519	PI 176488	Turkey	8.0	8.0	7.3	8.0	8.0	8.0	8.0
520	PI 178870	Turkey	8.0	8.0	7.3	8.0	8.0	8.0	8.0
521	PI 179875	India	8.0	8.0	7.3	8.0	8.0	9.0	7.0
522	PI 183399	India	8.0	8.0	7.3	8.0	8.0	8.0	8.0
523	PI 254742	Senegal	8.0	8.0	7.3	8.0	8.0	8.0	8.0
524	PI 274785	India	8.0	8.0	7.3	8.0	8.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
525	PI 534530	Syria	8.0	8.0	7.3	8.0	9.0	8.0	7.0
526	PI 537274	Pakistan	8.0	8.0	7.3	9.0	8.0	7.0	8.0
527	PI 593347	China	8.0	8.0	7.3	8.0	8.0	8.0	8.0
528	PI 246029	Chile	8.0	8.0	7.3	8.0	8.0	8.0	8.0
529	PI 270308	Philippines	8.0	8.0	7.3	8.0	8.0	8.0	8.0
530	PI 270545	Sudan	8.0	8.0	7.3	8.0	7.0	8.0	9.0
531	PI 222714	Iran	8.0	8.0	7.3	7.0	8.0	8.0	9.0
532	PI 178873	Turkey	8.0	8.0	7.3	9.0	8.0	8.0	7.0
533	PI 270546	Ghana	8.0	8.0	7.3	8.0	8.0	8.0	8.0
534	PI 277995	Turkey	8.0	8.0	7.3	8.0	8.0	8.0	8.0
535	PI 278003	Turkey	8.0	8.0	7.3	8.0	8.0	8.0	8.0
536	PI 490385	Mali	8.0	8.0	7.3	-	8.0	8.0	8.0
537	PI 169293	Turkey	8.0	8.0	7.3	8.0	9.0	8.0	7.0
538	PI 193490	Ethiopia	8.0	8.0	7.3	8.0	8.0	8.0	8.0
539	PI 357727	Yugoslavia	8.0	8.0	7.3	8.0	8.0	8.0	8.0
540	PI 534583	Syria	8.0	8.0	7.3	8.0	8.0	8.0	8.0
541	Loafer	USA	8.0	8.0	7.3	9.0	-	7.0	8.0
542	PI 179237	Turkey	8.0	8.0	7.3	9.0	9.0	6.0	-
543	PI 507868	Hungary	8.0	8.0	7.3	-	8.0	8.0	8.0
544	PI 174105	Turkey	8.0	8.0	7.3	8.0	8.0	9.0	7.0
545	PI 179879	India	8.0	8.0	7.3	8.0	8.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
546	PI 226460	Iran	8.0	8.0	7.3	8.0	8.0	8.0	8.0
547	PI 269680	Belize	8.0	8.0	7.3	8.0	8.0	9.0	7.0
548	PI 270524	Israel	8.0	8.0	7.3	8.0	8.0	8.0	8.0
549	PI 276445	Jordan	8.0	8.0	7.3	8.0	8.0	8.0	8.0
550	PI 176492	Turkey	8.0	8.0	7.3	8.0	-	.	8.0
551	PI 217938	Pakistan	8.0	8.0	7.3	8.0	8.0	8.0	8.0
552	PI 222137	Algeria	8.0	8.0	7.3	8.0	8.0	8.0	8.0
553	PI 278043	Turkey	8.0	8.0	7.3	9.0	8.0	8.0	7.0
554	PI 179876	India	8.0	8.0	7.3	7.0	8.0	8.0	9.0
555	PI 211850	Iran	8.0	8.0	7.3	7.0	7.0	9.0	9.0
556	PI 271982	Somalia	8.0	8.0	7.4	8.0	7.0	8.0	9.0
557	PI 507862	Hungary	8.0	8.0	7.4	8.0	7.0	8.0	9.0
558	PI 182180	Turkey	8.0	8.0	7.4	8.0	8.0	8.0	8.0
559	PI 190050	Yugoslavia	8.0	8.0	7.4	8.0	8.0	8.0	8.0
560	PI 278017	Turkey	8.0	8.0	7.4	7.0	8.0	8.0	9.0
561	PI 179242	Iraq	8.0	8.0	7.4	8.0	7.0	8.0	9.0
562	PI 220779	Afghanistan	8.0	8.0	7.4	7.0	8.0	8.0	9.0
563	PI 226506	Iran	8.0	8.0	7.4	7.0	8.0	8.0	9.0
564	PI 226459	Iran	8.0	8.0	7.4	8.0	9.0	7.0	-
565	PI 532809	China	8.0	8.0	7.5	7.0	8.0	9.0	8.0
566	PI 179233	Turkey	8.0	8.0	7.5	8.0	8.0	9.0	7.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
567	PI 254739	Senegal	8.0	8.0	7.5	8.0	8.0	8.0	8.0
568	PI 211851	Iran	8.0	8.0	7.5	8.0	8.0	8.0	8.0
569	PI 269678	Belize	8.0	8.0	7.5	8.0	8.0	8.0	8.0
570	PI 278012	Turkey	8.0	8.0	7.5	7.0	8.0	8.0	9.0
571	PI 179238	Turkey	8.0	8.0	7.6	8.0	7.0	8.0	9.0
572	PI 240533	Iran	8.0	8.0	7.8	-	7.0	-	9.0
573	PI 596677	S. Africa	8.3	8.3	6.5	8.0	8.0	9.0	8.0
574	PI 494527	Nigeria	8.3	8.3	6.6	8.0	8.0	8.0	9.0
575	PI 559994	Nigeria	8.3	8.3	6.8	9.0	8.0	9.0	7.0
576	PI 593368	China	8.3	8.3	6.8	8.0	9.0	8.0	8.0
577	PI 532722	Zaire	8.3	8.3	6.9	8.0	8.0	9.0	8.0
578	PI 593358	China	8.3	8.3	7.0	8.0	8.0	8.0	9.0
579	PI 185635	Ghana	8.3	8.3	7.0	8.0	9.0	8.0	8.0
580	PI 381751	India	8.3	8.3	7.0	8.0	8.0	9.0	8.0
581	PI 482320	Zimbabwe	8.3	8.3	7.0	8.0	8.0	8.0	9.0
582	PI 494816	Zambia	8.3	8.3	7.0	8.0	9.0	8.0	8.0
583	PI 500332	Zambia	8.3	8.3	7.0	8.0	8.0	9.0	8.0
584	PI 560006	Nigeria	8.3	8.3	7.0	8.0	8.0	8.0	9.0
585	PI 593345	China	8.3	8.3	7.0	8.0	8.0	8.0	9.0
586	PI 482259	Zimbabwe	8.3	8.3	7.0	8.0	8.0	8.0	9.0
587	PI 482348	Zimbabwe	8.3	8.3	7.0	8.0	8.0	8.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
588	PI 482376	Zimbabwe	8.3	8.3	7.0	8.0	8.0	9.0	8.0
589	PI 559993	Nigeria	8.3	8.3	7.0	8.0	9.0	8.0	8.0
590	PI 632751	Namibia	8.3	8.3	7.0	8.0	8.0	8.0	9.0
591	PI 560000	Nigeria	8.3	8.3	7.0	7.0	8.0	9.0	9.0
592	PI 482285	Zimbabwe	8.3	8.3	7.0	8.0	8.0	8.0	9.0
593	PI 500352	Zambia	8.3	8.3	7.0	8.0	8.0	8.0	9.0
594	PI 163574	Guatemala	8.3	8.3	7.1	8.0	8.0	8.0	9.0
595	PI 169232	Turkey	8.3	8.3	7.1	8.0	8.0	9.0	8.0
596	PI 381706	India	8.3	8.3	7.1	8.0	8.0	8.0	9.0
597	PI 381709	India	8.3	8.3	7.1	8.0	8.0	8.0	9.0
598	PI 482270	Zimbabwe	8.3	8.3	7.1	8.0	8.0	9.0	8.0
599	PI 482313	Zimbabwe	8.3	8.3	7.1	8.0	8.0	8.0	9.0
600	PI 482317	Zimbabwe	8.3	8.3	7.1	8.0	8.0	9.0	8.0
601	PI 494820	Zambia	8.3	8.3	7.1	8.0	8.0	8.0	9.0
602	PI 494821	Zambia	8.3	8.3	7.1	8.0	8.0	9.0	8.0
603	PI 534591	Syria	8.3	8.3	7.1	8.0	9.0	8.0	8.0
604	PI 536448	Maldives	8.3	8.3	7.1	8.0	8.0	8.0	9.0
605	PI 593383	China	8.3	8.3	7.1	8.0	8.0	8.0	9.0
606	PI 612469	Korea	8.3	8.3	7.1	8.0	8.0	8.0	9.0
607	PI 357741	Yugoslavia	8.3	8.3	7.1	9.0	8.0	8.0	8.0
608	PI 482329	Zimbabwe	8.3	8.3	7.1	8.0	8.0	8.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
609	PI 534533	Syria	8.3	8.3	7.1	8.0	8.0	8.0	9.0
609	PI 534533	Syria	8.3	8.3	7.1	8.0	8.0	8.0	9.0
610	Tendergold	USA	8.3	8.3	7.1	8.0	8.0	9.0	8.0
611	Honey Red	USA	8.3	8.3	7.1	9.0	8.0	8.0	8.0
612	PI 169261	Turkey	8.3	8.3	7.1	8.0	8.0	9.0	8.0
613	PI 169280	Turkey	8.3	8.3	7.1	9.0	8.0	8.0	8.0
614	PI 251515	Iran	8.3	8.3	7.1	9.0	8.0	8.0	8.0
615	PI 357682	Yugoslavia	8.3	8.3	7.1	9.0	8.0	8.0	8.0
616	PI 482346	Zimbabwe	8.3	8.3	7.1	8.0	8.0	8.0	9.0
617	PI 482364	Zimbabwe	8.3	8.3	7.1	8.0	8.0	8.0	9.0
618	PI 500312	Zambia	8.3	8.3	7.1	8.0	9.0	8.0	8.0
619	PI 500342	Zambia	8.3	8.3	7.1	8.0	8.0	9.0	8.0
620	PI 505591	Zambia	8.3	8.3	7.1	8.0	9.0	8.0	8.0
621	PI 525088	Egypt	8.3	8.3	7.1	8.0	8.0	9.0	8.0
622	PI 526231	Zimbabwe	8.3	8.3	7.1	9.0	8.0	8.0	8.0
623	PI 532733	Zimbabwe	8.3	8.3	7.1	8.0	8.0	8.0	9.0
624	PI 561138	Kazakhstan	8.3	8.3	7.1	8.0	9.0	8.0	8.0
625	PI 482251	Zimbabwe	8.3	8.3	7.2	9.0	8.0	8.0	8.0
626	PI 482290	Zimbabwe	8.3	8.3	7.2	8.0	8.0	9.0	8.0
627	PI 169234	Turkey	8.3	8.3	7.2	8.0	9.0	8.0	8.0
628	PI 169291	Turkey	8.3	8.3	7.2	9.0	8.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
629	PI 229604	Iran	8.3	8.3	7.2	8.0	8.0	8.0	9.0
630	PI 254738	Senegal	8.3	8.3	7.2	8.0	8.0	9.0	8.0
631	PI 278047	Turkey	8.3	8.3	7.2	8.0	8.0	8.0	9.0
632	PI 379247	Yugoslavia	8.3	8.3	7.2	8.0	8.0	8.0	9.0
633	PI 512833	Spain	8.3	8.3	7.2	8.0	7.0	9.0	9.0
634	PI 526237	Zimbabwe	8.3	8.3	7.2	8.0	8.0	9.0	8.0
635	PI 278018	Turkey	8.3	8.3	7.2	9.0	8.0	8.0	8.0
636	PI 534597	Syria	8.3	8.3	7.2	8.0	8.0	9.0	8.0
637	PI 542115	Botswana	8.3	8.3	7.2	8.0	8.0	9.0	8.0
638	PI 505589	Zambia	8.3	8.3	7.2	9.0	8.0	8.0	8.0
639	PI 500321	Zambia	8.3	8.3	7.2	8.0	8.0	8.0	9.0
640	Charleston Gray	USA	8.3	8.3	7.2	8.0	8.0	9.0	8.0
641	PI 164543	India	8.3	8.3	7.2	8.0	9.0	8.0	8.0
642	PI 169284	Turkey	8.3	8.3	7.2	8.0	8.0	8.0	9.0
643	PI 174106	Turkey	8.3	8.3	7.2	9.0	8.0	8.0	8.0
644	PI 176485	Turkey	8.3	8.3	7.2	9.0	8.0	8.0	8.0
645	PI 254735	Senegal	8.3	8.3	7.2	8.0	8.0	9.0	8.0
646	PI 278048	Turkey	8.3	8.3	7.2	7.0	8.0	9.0	9.0
647	PI 278060	Turkey	8.3	8.3	7.2	9.0	8.0	8.0	8.0
648	PI 288232	Egypt	8.3	8.3	7.2	8.0	8.0	8.0	9.0
649	PI 307748	Philippines	8.3	8.3	7.2	9.0	7.0	8.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
650	PI 357666	Yugoslavia	8.3	8.3	7.2	8.0	9.0	8.0	8.0
651	PI 370015	India	8.3	8.3	7.2	9.0	8.0	8.0	8.0
652	PI 378611	Zaire	8.3	8.3	7.2	8.0	9.0	8.0	8.0
653	PI 379224	Yugoslavia	8.3	8.3	7.2	8.0	9.0	8.0	8.0
654	PI 381697	India	8.3	8.3	7.2	8.0	8.0	8.0	9.0
655	PI 381721	India	8.3	8.3	7.2	8.0	8.0	8.0	9.0
656	PI 482254	Zimbabwe	8.3	8.3	7.2	8.0	8.0	8.0	9.0
657	PI 482266	Zimbabwe	8.3	8.3	7.2	8.0	9.0	8.0	8.0
658	PI 482284	Zimbabwe	8.3	8.3	7.2	8.0	8.0	9.0	8.0
659	PI 490380	Mali	8.3	8.3	7.2	8.0	8.0	9.0	8.0
660	PI 500333	Zambia	8.3	8.3	7.2	8.0	8.0	8.0	9.0
661	PI 500345	Zambia	8.3	8.3	7.2	8.0	9.0	8.0	8.0
662	PI 512356	Spain	8.3	8.3	7.2	8.0	9.0	8.0	8.0
663	PI 512391	Spain	8.3	8.3	7.2	8.0	8.0	8.0	9.0
664	PI 526239	Zimbabwe	8.3	8.3	7.2	8.0	8.0	9.0	8.0
665	PI 532810	China	8.3	8.3	7.2	8.0	8.0	9.0	8.0
666	PI 534531	Syria	8.3	8.3	7.2	8.0	8.0	8.0	9.0
667	PI 537275	Pakistan	8.3	8.3	7.2	8.0	8.0	9.0	8.0
668	PI 537471	Spain	8.3	8.3	7.2	8.0	8.0	9.0	8.0
669	PI 543212	Bolivia	8.3	8.3	7.2	8.0	9.0	8.0	8.0
670	PI 593343	China	8.3	8.3	7.2	8.0	8.0	8.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
671	PI 593348	China	8.3	8.3	7.2	8.0	9.0	8.0	8.0
672	PI 612462	Korea S.	8.3	8.3	7.2	8.0	8.0	8.0	9.0
673	PI 612472	Korea S.	8.3	8.3	7.2	8.0	9.0	8.0	8.0
674	PI 176906	Turkey	8.3	8.3	7.2	8.0	8.0	8.0	9.0
675	PI 181740	Lebanon	8.3	8.3	7.2	9.0	8.0	8.0	8.0
676	PI 228238	Israel	8.3	8.3	7.2	8.0	8.0	8.0	9.0
677	PI 344066	Turkey	8.3	8.3	7.2	9.0	8.0	8.0	8.0
678	PI 345543	Ukraine	8.3	8.3	7.2	7.0	9.0	9.0	8.0
679	PI 357659	Yugoslavia	8.3	8.3	7.2	8.0	9.0	8.0	8.0
680	PI 381749	India	8.3	8.3	7.2	8.0	9.0	8.0	8.0
681	PI 512339	Spain	8.3	8.3	7.2	8.0	8.0	8.0	9.0
682	PI 185030	Turkey	8.3	8.3	7.2	9.0	8.0	8.0	8.0
683	PI 222712	Iran	8.3	8.3	7.2	8.0	8.0	8.0	9.0
684	Grif 5597	India	8.3	8.3	7.3	8.0	8.0	8.0	9.0
685	PI 177321	Turkey	8.3	8.3	7.3	9.0	8.0	8.0	8.0
686	PI 500318	Zambia	8.3	8.3	7.3	8.0	8.0	8.0	9.0
687	PI 508444	Korea,S	8.3	8.3	7.3	9.0	9.0	7.0	8.0
688	Carolina Cross	USA	8.3	8.3	7.3	9.0	8.0	8.0	8.0
689	Grif 1733	China	8.3	8.3	7.3	9.0	8.0	8.0	8.0
690	PI 165448	Mexico	8.3	8.3	7.3	9.0	8.0	8.0	8.0
691	PI 167124	Turkey	8.3	8.3	7.3	8.0	9.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
692	PI 169252	Turkey	8.3	8.3	7.3	8.0	9.0	8.0	8.0
693	PI 271985	Somalia	8.3	8.3	7.3	9.0	8.0	8.0	8.0
694	PI 325248	Soviet Union	8.3	8.3	7.3	8.0	9.0	8.0	8.0
695	PI 357686	Yugoslavia	8.3	8.3	7.3	8.0	8.0	8.0	9.0
696	PI 370431	Yugoslavia	8.3	8.3	7.3	9.0	8.0	8.0	8.0
697	PI 381712	India	8.3	8.3	7.3	8.0	9.0	8.0	8.0
698	PI 482247	Zimbabwe	8.3	8.3	7.3	8.0	8.0	8.0	9.0
699	PI 482325	Zimbabwe	8.3	8.3	7.3	8.0	8.0	8.0	9.0
700	PI 482337	Zimbabwe	8.3	8.3	7.3	8.0	8.0	8.0	9.0
701	PI 482349	Zimbabwe	8.3	8.3	7.3	8.0	8.0	9.0	8.0
702	PI 482354	Zimbabwe	8.3	8.3	7.3	8.0	8.0	8.0	9.0
703	PI 482372	Zimbabwe	8.3	8.3	7.3	8.0	9.0	8.0	8.0
704	PI 508443	Korea, South	8.3	8.3	7.3	9.0	8.0	8.0	8.0
705	PI 518609	Soviet Union	8.3	8.3	7.3	9.0	8.0	8.0	8.0
706	PI 537268	Pakistan	8.3	8.3	7.3	8.0	8.0	9.0	8.0
707	PI 549162	Chad	8.3	8.3	7.3	8.0	9.0	8.0	8.0
708	PI 593378	China	8.3	8.3	7.3	8.0	9.0	8.0	8.0
709	PI 593390	China	8.3	8.3	7.3	9.0	8.0	8.0	8.0
710	PI 612467	Korea	8.3	8.3	7.3	8.0	9.0	8.0	8.0
711	Grif 5596	India	8.3	8.3	7.3	7.0	9.0	9.0	8.0
712	PI 169233	Turkey	8.3	8.3	7.3	8.0	9.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
713	PI 169297	Turkey	8.3	8.3	7.3	8.0	8.0	9.0	8.0
714	PI 172794	Turkey	8.3	8.3	7.3	8.0	8.0	8.0	9.0
715	PI 174099	Turkey	8.3	8.3	7.3	8.0	9.0	8.0	8.0
716	PI 174100	Turkey	8.3	8.3	7.3	9.0	8.0	8.0	8.0
717	PI 175651	Turkey	8.3	8.3	7.3	9.0	8.0	8.0	8.0
718	PI 175661	Turkey	8.3	8.3	7.3	8.0	9.0	8.0	8.0
719	PI 176494	Turkey	8.3	8.3	7.3	8.0	8.0	9.0	8.0
720	PI 179243	Turkey	8.3	8.3	7.3	8.0	9.0	8.0	8.0
721	PI 179877	India	8.3	8.3	7.3	8.0	8.0	8.0	9.0
722	PI 182181	Turkey	8.3	8.3	7.3	8.0	9.0	8.0	8.0
723	PI 278020	Turkey	8.3	8.3	7.3	9.0	9.0	7.0	8.0
724	PI 278022	Turkey	8.3	8.3	7.3	9.0	8.0	8.0	8.0
725	PI 278054	Turkey	8.3	8.3	7.3	9.0	8.0	8.0	8.0
726	PI 357675	Yugoslavia	8.3	8.3	7.3	7.0	8.0	9.0	9.0
727	PI 357701	Yugoslavia	8.3	8.3	7.3	9.0	8.0	8.0	8.0
728	PI 357725	Yugoslavia	8.3	8.3	7.3	8.0	8.0	8.0	9.0
729	PI 370426	Yugoslavia	8.3	8.3	7.3	8.0	9.0	7.0	9.0
730	PI 379229	Yugoslavia	8.3	8.3	7.3	8.0	8.0	9.0	8.0
731	PI 482363	Zimbabwe	8.3	8.3	7.3	8.0	8.0	9.0	8.0
732	PI 502315	Ukraine	8.3	8.3	7.3	8.0	9.0	8.0	8.0
733	PI 512358	Spain	8.3	8.3	7.3	8.0	9.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
734	PI 512389	Spain	8.3	8.3	7.3	8.0	8.0	9.0	8.0
735	PI 518608	Russi	8.3	8.3	7.3	9.0	8.0	8.0	8.0
736	PI 525094	Egypt	8.3	8.3	7.3	8.0	8.0	9.0	8.0
737	PI 525098	Egypt	8.3	8.3	7.3	8.0	8.0	9.0	8.0
738	PI 534590	Syria	8.3	8.3	7.3	9.0	8.0	8.0	8.0
739	PI 534598	Syria	8.3	8.3	7.3	8.0	9.0	8.0	8.0
740	PI 537273	Pakistan	8.3	8.3	7.3	8.0	8.0	9.0	8.0
741	PI 538888	Soviet Unionn	8.3	8.3	7.3	8.0	9.0	8.0	8.0
742	PI 593369	China	8.3	8.3	7.3	8.0	9.0	8.0	8.0
743	PI 593373	China	8.3	8.3	7.3	8.0	8.0	8.0	9.0
744	PI 629111	USA	8.3	8.3	7.3	8.0	9.0	8.0	8.0
745	PI 632754	Bulgaria	8.3	8.3	7.3	8.0	9.0	8.0	8.0
746	PI 169279	Turkey	8.3	8.3	7.3	8.0	8.0	8.0	9.0
747	PI 176490	Turkey	8.3	8.3	7.3	8.0	8.0	8.0	9.0
748	PI 357751	Yugoslavia	8.3	8.3	7.3	8.0	8.0	8.0	9.0
749	PI 368527	Yugoslavia	8.3	8.3	7.3	9.0	8.0	8.0	8.0
750	PI 512341	Spain	8.3	8.3	7.3	9.0	7.0	9.0	8.0
751	PI 279461	Japan	8.3	8.3	7.3	8.0	8.0	8.0	9.0
752	PI 490381	Mali	8.3	8.3	7.3	8.0	8.0	9.0	8.0
753	PI 500315	Zambia	8.3	8.3	7.3	8.0	8.0	8.0	9.0
754	PI 505585	Zambia	8.3	8.3	7.3	8.0	9.0	9.0	7.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
755	PI 278015	Turkey	8.3	8.3	7.3	8.0	7.0	9.0	9.0
756	PI 481871	Sudan	8.3	8.3	7.3	9.0	7.0	8.0	9.0
757	PI 164665	India	8.3	8.3	7.3	8.0	8.0	8.0	9.0
758	PI 172803	Turkey	8.3	8.3	7.3	8.0	9.0	8.0	8.0
759	PI 426625	Pakistan	8.3	8.3	7.3	9.0	8.0	8.0	8.0
760	PI 500305	Zambia	8.3	8.3	7.3	9.0	8.0	8.0	8.0
761	PI 500353	Zambia	8.3	8.3	7.3	9.0	8.0	8.0	8.0
762	PI 507863	Hungary	8.3	8.3	7.3	8.0	9.0	8.0	8.0
763	PI 512403	Spain	8.3	8.3	7.3	9.0	8.0	8.0	8.0
764	PI 612458	Korea	8.3	8.3	7.3	8.0	9.0	8.0	8.0
765	Graybelle	USA	8.3	8.3	7.3	9.0	8.0	8.0	8.0
766	PI 163202	India	8.3	8.3	7.3	8.0	9.0	8.0	8.0
767	PI 169272	Turkey	8.3	8.3	7.3	8.0	9.0	8.0	8.0
768	PI 173668	Turkey	8.3	8.3	7.3	8.0	9.0	8.0	8.0
769	PI 273481	Ethiopia	8.3	8.3	7.3	8.0	9.0	8.0	8.0
770	PI 277970	Turkey	8.3	8.3	7.3	9.0	8.0	8.0	8.0
771	PI 278031	Turkey	8.3	8.3	7.3	9.0	8.0	8.0	8.0
772	PI 278050	Turkey	8.3	8.3	7.3	8.0	8.0	8.0	9.0
773	PI 278056	Turkey	8.3	8.3	7.3	8.0	8.0	9.0	8.0
774	PI 357689	Yugoslavia	8.3	8.3	7.3	8.0	8.0	8.0	9.0
775	PI 357711	Yugoslavia	8.3	8.3	7.3	8.0	9.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
776	PI 370427	Yugoslavia	8.3	8.3	7.3	8.0	8.0	8.0	9.0
777	PI 379230	Yugoslavia	8.3	8.3	7.3	9.0	8.0	8.0	8.0
778	PI 508441	Korea,S	8.3	8.3	7.3	9.0	8.0	8.0	8.0
779	PI 512350	Spain	8.3	8.3	7.3	8.0	8.0	8.0	9.0
780	PI 512353	Spain	8.3	8.3	7.3	8.0	8.0	8.0	9.0
781	PI 632752	USA	8.3	8.3	7.3	8.0	9.0	8.0	8.0
782	PI 175658	Turkey	8.3	8.3	7.3	9.0	8.0	8.0	8.0
783	PI 181743	Lebanon	8.3	8.3	7.3	9.0	8.0	8.0	8.0
784	PI 182178	Turkey	8.3	8.3	7.3	9.0	8.0	8.0	8.0
785	PI 211011	Afghanistan	8.3	8.3	7.3	8.0	9.0	8.0	8.0
786	PI 274561	Portugal	8.3	8.3	7.3	9.0	8.0	8.0	8.0
787	PI 276658	Soviet Union	8.3	8.3	7.3	8.0	8.0	8.0	9.0
788	PI 278061	Turkey	8.3	8.3	7.3	8.0	8.0	9.0	8.0
789	PI 368500	Yugoslavia	8.3	8.3	7.3	8.0	8.0	8.0	9.0
790	PI 507861	Hungary	8.3	8.3	7.3	8.0	9.0	8.0	8.0
791	PI 482373	Zimbabwe	8.3	8.3	7.3	8.0	8.0	9.0	8.0
792	PI 508442	Korea, South	8.3	8.3	7.3	8.0	9.0	8.0	8.0
793	PI 164570	India	8.3	8.3	7.3	7.0	9.0	9.0	8.0
794	PI 171581	Turkey	8.3	8.3	7.3	8.0	9.0	7.0	9.0
795	PI 182176	Turkey	8.3	8.3	7.3	8.0	8.0	9.0	8.0
796	PI 182183	Turkey	8.3	8.3	7.3	8.0	9.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
797	PI 278008	Turkey	8.3	8.3	7.3	8.0	8.0	8.0	9.0
798	PI 307749	Philippines	8.3	8.3	7.3	9.0	7.0	8.0	9.0
799	PI 368506	Yugoslavia	8.3	8.3	7.3	9.0	8.0	8.0	8.0
800	PI 512345	Spain	8.3	8.3	7.3	8.0	9.0	8.0	8.0
801	PI 512387	Spain	8.3	8.3	7.3	8.0	8.0	8.0	9.0
802	PI 512397	Spain	8.3	8.3	7.3	9.0	8.0	8.0	8.0
803	PI 169294	Turkey	8.3	8.3	7.3	9.0	7.0	9.0	8.0
804	PI 172791	Turkey	8.3	8.3	7.3	8.0	9.0	9.0	7.0
805	PI 381694	India	8.3	8.3	7.3	8.0	8.0	8.0	9.0
806	Mtn. Hoosier	USA	8.3	8.3	7.4	8.0	8.0	8.0	9.0
807	PI 171587	Turkey	8.3	8.3	7.4	8.0	8.0	8.0	9.0
808	PI 234605	USA	8.3	8.3	7.4	8.0	9.0	8.0	8.0
809	PI 275631	India	8.3	8.3	7.4	8.0	8.0	8.0	9.0
810	PI 276659	Soviet Union	8.3	8.3	7.4	8.0	9.0	8.0	8.0
811	PI 278007	Turkey	8.3	8.3	7.4	7.0	9.0	9.0	8.0
812	Long Crimson	USA	8.3	8.3	7.4	8.0	9.0	8.0	8.0
813	PI 169260	Turkey	8.3	8.3	7.4	8.0	8.0	8.0	9.0
814	PI 179235	Turkey	8.3	8.3	7.4	9.0	8.0	8.0	8.0
815	PI 378615	Zaire	8.3	8.3	7.4	8.0	8.0	9.0	8.0
816	PI 379252	Yugoslavia	8.3	8.3	7.4	8.0	8.0	8.0	9.0
817	PI 357690	Yugoslavia	8.3	8.3	7.4	7.0	8.0	9.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
818	PI 508445	South Korea	8.3	8.3	7.4	8.0	8.0	8.0	9.0
819	PI 210017	India	8.3	8.3	7.4	8.0	8.0	8.0	9.0
820	PI 381708	India	8.3	8.3	7.4	8.0	9.0	8.0	8.0
821	PI 162667	Argentina	8.3	8.3	7.4	8.0	9.0	8.0	8.0
822	PI 172788	Turkey	8.3	8.3	7.4	8.0	8.0	8.0	9.0
823	PI 182933	India	8.3	8.3	7.4	8.0	8.0	9.0	8.0
824	PI 222776	Iran	8.3	8.3	7.4	8.0	9.0	8.0	8.0
825	PI 270307	Philippines	8.3	8.3	7.4	8.0	9.0	8.0	8.0
826	PI 482366	Zimbabwe	8.3	8.3	7.4	8.0	8.0	9.0	8.0
827	PI 169290	Turkey	8.3	8.3	7.4	8.0	9.0	8.0	8.0
828	PI 178872	Turkey	8.3	8.3	7.4	8.0	8.0	8.0	9.0
829	PI 181741	Lebanon	8.3	8.3	7.4	7.0	9.0	9.0	8.0
830	PI 181938	Syria	8.3	8.3	7.4	8.0	9.0	8.0	8.0
831	PI 183299	India	8.3	8.3	7.4	8.0	8.0	8.0	9.0
832	PI 242906	Afghanistan	8.3	8.3	7.4	8.0	8.0	8.0	9.0
833	PI 266028	Venezuela	8.3	8.3	7.4	9.0	8.0	8.0	8.0
834	PI 277981	Turkey	8.3	8.3	7.4	8.0	9.0	8.0	8.0
835	PI 277994	Turkey	8.3	8.3	7.4	8.0	8.0	9.0	8.0
836	PI 278036	Turkey	8.3	8.3	7.4	9.0	8.0	8.0	8.0
837	PI 357699	Yugoslavia	8.3	8.3	7.4	8.0	9.0	8.0	8.0
838	PI 368524	Yugoslavia	8.3	8.3	7.4	9.0	7.0	9.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
839	PI 438676	Mexico	8.3	8.3	7.4	8.0	9.0	7.0	9.0
840	PI 536462	Maldives	8.3	8.3	7.4	9.0	8.0	7.0	9.0
841	PI 211917	Iran	8.3	8.3	7.4	9.0	8.0	7.0	9.0
842	PI 368513	Yugoslavia	8.3	8.3	7.4	7.0	9.0	8.0	9.0
843	PI 164685	India	8.3	8.3	7.5	8.0	9.0	8.0	8.0
844	PI 629110	USA	8.3	8.3	7.5	8.0	9.0	8.0	8.0
845	Grif 1728	China	8.3	8.3	7.5	8.0	8.0	8.0	9.0
846	PI 176910	Turkey	8.3	8.3	7.5	9.0	8.0	8.0	8.0
847	PI 274795	Pakistan	8.3	8.3	7.5	9.0	8.0	8.0	8.0
848	PI 278044	Turkey	8.3	8.3	7.5	8.0	8.0	9.0	8.0
849	PI 502318	Uzbekistan	8.3	8.3	7.5	8.0	9.0	8.0	8.0
850	PI 171586	Turkey	8.3	8.3	7.5	8.0	9.0	8.0	8.0
851	PI 183124	India	8.3	8.3	7.5	9.0	9.0	8.0	7.0
852	PI 278016	Turkey	8.3	8.3	7.5	8.0	9.0	9.0	7.0
853	PI 357678	Yugoslavia	8.3	8.3	7.5	9.0	8.0	8.0	8.0
854	PI 212287	Afghanistan	8.3	8.3	7.5	8.0	8.0	8.0	9.0
855	PI 277998	Turkey	8.3	8.3	7.5	8.0	8.0	8.0	9.0
856	PI 381742	India	8.3	8.3	7.5	7.0	8.0	9.0	9.0
857	PI 270309	Philippines	8.3	8.3	7.6	9.0	8.0	8.0	8.0
858	PI 381720	India	8.3	8.3	7.6	8.0	8.0	8.0	9.0
859	PI 270144	Greece	8.3	8.3	7.6	8.0	9.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
860	PI 357733	Yugoslavia	8.3	8.3	7.6	9.0	8.0	8.0	8.0
861	PI 183217	Egypt	8.3	8.3	7.7	8.0	9.0	8.0	8.0
862	PI 177331	Syria	8.3	8.3	7.7	8.0	9.0	8.0	8.0
863	PI 278001	Turkey	8.3	8.3	7.7	8.0	8.0	8.0	9.0
864	PI 211849	Iran	8.3	8.3	7.7	9.0	8.0	8.0	8.0
865	PI 169276	Turkey	8.3	8.3	7.7	8.0	9.0	8.0	8.0
866	PI 176491	Turkey	8.3	8.3	7.7	7.0	9.0	8.0	9.0
867	PI 193965	Ethiopia	8.3	8.3	7.7	9.0	8.0	8.0	8.0
868	PI 270525	Israel	8.3	8.3	7.7	9.0	9.0	8.0	7.0
869	PI 271983	Somalia	8.3	8.3	7.7	8.0	8.0	8.0	9.0
870	PI 277980	Turkey	8.3	8.3	7.7	8.0	9.0	7.0	9.0
871	PI 174103	Turkey	8.3	8.3	7.8	9.0	8.0	7.0	9.0
872	PI 176495	Turkey	8.3	8.3	7.8	9.0	8.0	8.0	8.0
873	PI 182934	India	8.3	8.3	7.8	9.0	9.0	8.0	7.0
874	PI 222710	Iran	8.3	8.3	7.8	9.0	9.0	8.0	7.0
875	PI 278023	Turkey	8.3	8.3	7.8	9.0	9.0	8.0	7.0
876	PI 222711	Iran	8.3	8.3	7.8	9.0	8.0	8.0	8.0
877	Tastigold	USA	8.3	8.3	7.0	-	8.0	8.0	9.0
878	PI 277988	Turkey	8.3	8.3	7.2	8.0	-	8.0	9.0
879	PI 379250	Yugoslavia	8.3	8.3	7.2	9.0	8.0	-	8.0
880	PI 270565	S. Africa	8.3	8.3	7.2	8.0	8.0	-	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
881	PI 177319	Turkey	8.3	8.3	7.3	8.0	8.0	9.0	-
882	PI 278002	Turkey	8.3	8.3	7.3	9.0	8.0	8.0	-
883	PI 346082	Afghanistan	8.3	8.3	7.3	8.0	-	9.0	8.0
884	PI 357739	Yugoslavia	8.3	8.3	7.3	8.0	-	8.0	9.0
885	PI 490383	Mali	8.3	8.3	7.3	8.0	9.0	-	8.0
886	PI 164737	India	8.3	8.3	7.3	8.0	8.0	-	9.0
887	PI 279456	Japan	8.3	8.3	7.3	9.0	8.0	8.0	-
888	Early Canada	USA	8.3	8.3	7.4	8.0	9.0	8.0	-
889	PI 381719	India	8.3	8.3	7.4	8.0	-	8.0	9.0
890	PI 357728	Yugoslavia	8.3	8.3	7.6	8.0	8.0	9.0	-
891	PI 270145	Greece	8.3	8.3	7.7	8.0	8.0	-	9.0
892	PI 269681	Belize	8.3	8.3	8.0	-	9.0	8.0	8.0
893	PI 596676	S. Africa	8.5	8.5	6.6	9.0	8.0	8.0	9.0
894	PI 560024	Nigeria	8.5	8.5	6.8	9.0	9.0	8.0	8.0
895	PI 296337	S. Africa	8.5	8.5	6.8	7.0	9.0	9.0	9.0
896	PI 482295	Zimbabwe	8.5	8.5	7.0	9.0	9.0	8.0	8.0
897	PI 560007	Nigeria	8.5	8.5	7.0	9.0	8.0	8.0	9.0
898	PI 532732	Zimbabwe	8.5	8.5	7.1	8.0	8.0	9.0	9.0
899	PI 228342	Iran	8.5	8.5	7.2	9.0	9.0	8.0	8.0
900	PI 381695	India	8.5	8.5	7.2	8.0	9.0	8.0	9.0
901	PI 593376	China	8.5	8.5	7.2	9.0	9.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
902	PI 482260	Zimbabwe	8.5	8.5	7.2	9.0	8.0	9.0	8.0
903	PI 161373	Korea	8.5	8.5	7.2	9.0	9.0	8.0	8.0
904	PI 560901	China	8.5	8.5	7.2	9.0	8.0	8.0	9.0
905	PI 593349	China	8.5	8.5	7.2	8.0	8.0	9.0	9.0
906	PI 174107	Turkey	8.5	8.5	7.2	9.0	8.0	8.0	9.0
907	PI 379234	Yugoslavia	8.5	8.5	7.3	9.0	8.0	8.0	9.0
908	Grif 1734	China	8.5	8.5	7.3	9.0	9.0	8.0	8.0
909	PI 167125	Turkey	8.5	8.5	7.3	9.0	8.0	9.0	8.0
910	PI 169235	Turkey	8.5	8.5	7.3	9.0	8.0	8.0	9.0
911	PI 169245	Turkey	8.5	8.5	7.3	9.0	9.0	8.0	8.0
912	PI 169263	Turkey	8.5	8.5	7.3	9.0	9.0	8.0	8.0
913	PI 172796	Turkey	8.5	8.5	7.3	8.0	9.0	9.0	8.0
914	PI 175656	Turkey	8.5	8.5	7.3	9.0	9.0	8.0	8.0
915	PI 176497	Turkey	8.5	8.5	7.3	8.0	9.0	9.0	8.0
916	PI 254430	Lebanon	8.5	8.5	7.3	9.0	8.0	8.0	9.0
917	PI 254624	Sudan	8.5	8.5	7.3	9.0	8.0	9.0	8.0
918	PI 277992	Turkey	8.5	8.5	7.3	8.0	9.0	9.0	8.0
919	PI 278049	Turkey	8.5	8.5	7.3	8.0	8.0	9.0	9.0
920	PI 370428	Yugoslavia	8.5	8.5	7.3	9.0	8.0	9.0	8.0
921	PI 379228	Yugoslavia	8.5	8.5	7.3	9.0	8.0	8.0	9.0
922	PI 381711	India	8.5	8.5	7.3	9.0	9.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
923	PI 381739	India	8.5	8.5	7.3	9.0	9.0	8.0	8.0
924	PI 470246	Indonesia	8.5	8.5	7.3	9.0	9.0	8.0	8.0
925	PI 476326	Soviet Union	8.5	8.5	7.3	9.0	8.0	8.0	9.0
926	PI 476328	Soviet Union	8.5	8.5	7.3	8.0	8.0	9.0	9.0
927	PI 482291	Zimbabwe	8.5	8.5	7.3	8.0	9.0	9.0	8.0
928	PI 482343	Zimbabwe	8.5	8.5	7.3	8.0	9.0	8.0	9.0
929	PI 512342	Spain	8.5	8.5	7.3	8.0	8.0	9.0	9.0
930	PI 534589	Syria	8.5	8.5	7.3	8.0	9.0	9.0	8.0
931	PI 105445	Turkey	8.5	8.5	7.3	9.0	9.0	8.0	8.0
932	PI 172793	Turkey	8.5	8.5	7.3	8.0	9.0	9.0	8.0
933	PI 357745	Yugoslavia	8.5	8.5	7.3	8.0	9.0	8.0	9.0
934	PI 370429	Yugoslavia	8.5	8.5	7.3	8.0	9.0	9.0	8.0
935	PI 435991	China	8.5	8.5	7.3	8.0	8.0	9.0	9.0
936	PI 482345	Zimbabwe	8.5	8.5	7.3	8.0	8.0	9.0	9.0
937	PI 512383	Spain	8.5	8.5	7.3	7.0	9.0	9.0	9.0
938	PI 593350	China	8.5	8.5	7.3	9.0	9.0	8.0	8.0
939	PI 593355	China	8.5	8.5	7.3	9.0	9.0	8.0	8.0
940	PI 593356	China	8.5	8.5	7.3	9.0	8.0	9.0	8.0
941	PI 600896	USA	8.5	8.5	7.3	9.0	9.0	8.0	8.0
942	PI 482379	Zimbabwe	8.5	8.5	7.3	9.0	8.0	8.0	9.0
943	PI 357670	Yugoslavia	8.5	8.5	7.3	9.0	8.0	9.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
944	Grif 14199	India	8.5	8.5	7.3	8.0	8.0	9.0	9.0
945	Grif 1730	China	8.5	8.5	7.3	8.0	9.0	8.0	9.0
946	Grif 5595	India	8.5	8.5	7.3	8.0	9.0	9.0	8.0
947	PI 229806	USA	8.5	8.5	7.3	8.0	9.0	9.0	8.0
948	PI 357672	Yugoslavia	8.5	8.5	7.3	8.0	9.0	8.0	9.0
949	PI 381717	India	8.5	8.5	7.3	8.0	9.0	9.0	8.0
950	PI 490375	Mali	8.5	8.5	7.3	8.0	9.0	8.0	9.0
951	PI 502319	Uzbekistan	8.5	8.5	7.3	8.0	9.0	8.0	9.0
952	PI 512400	Spain	8.5	8.5	7.3	8.0	9.0	9.0	8.0
953	PI 543210	Bolivia	8.5	8.5	7.3	8.0	9.0	9.0	8.0
954	PI 593388	China	8.5	8.5	7.3	8.0	9.0	9.0	8.0
955	PI 600950	USA	8.5	8.5	7.3	9.0	8.0	8.0	9.0
956	PI 164539	India	8.5	8.5	7.3	9.0	8.0	9.0	8.0
957	PI 164550	India	8.5	8.5	7.3	8.0	9.0	9.0	8.0
958	PI 180276	India	8.5	8.5	7.3	9.0	8.0	8.0	9.0
959	PI 277991	Turkey	8.5	8.5	7.3	9.0	8.0	8.0	9.0
960	PI 277997	Turkey	8.5	8.5	7.3	9.0	9.0	8.0	8.0
961	PI 278011	Turkey	8.5	8.5	7.3	8.0	8.0	9.0	9.0
962	PI 357740	Yugoslavia	8.5	8.5	7.3	8.0	8.0	9.0	9.0
963	PI 368495	Yugoslavia	8.5	8.5	7.3	9.0	8.0	8.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
964	PI 482305	Zimbabwe	8.5	8.5	7.3	8.0	9.0	9.0	8.0
965	PI 512375	Spain	8.5	8.5	7.3	8.0	9.0	9.0	8.0
966	PI 593363	China	8.5	8.5	7.3	8.0	9.0	9.0	8.0
967	Perola	USA	8.5	8.5	7.3	9.0	8.0	9.0	8.0
968	PI 512367	Spain	8.5	8.5	7.3	9.0	8.0	8.0	9.0
969	PI 512394	Spain	8.5	8.5	7.3	8.0	8.0	9.0	9.0
970	PI 600902	USA	8.5	8.5	7.3	9.0	8.0	8.0	9.0
971	PI 113326	China	8.5	8.5	7.3	9.0	8.0	8.0	9.0
972	PI 164474	India	8.5	8.5	7.3	8.0	9.0	9.0	8.0
973	PI 175664	Turkey	8.5	8.5	7.3	8.0	9.0	9.0	8.0
974	PI 176919	Turkey	8.5	8.5	7.3	9.0	9.0	8.0	8.0
975	PI 271752	Ghana	8.5	8.5	7.3	8.0	8.0	9.0	9.0
976	PI 278027	Turkey	8.5	8.5	7.3	8.0	9.0	9.0	8.0
977	PI 278062	Turkey	8.5	8.5	7.3	8.0	9.0	9.0	8.0
978	PI 307609	Nigeria	8.5	8.5	7.3	8.0	8.0	9.0	9.0
979	PI 314236	Soviet Union	8.5	8.5	7.3	8.0	9.0	8.0	9.0
980	PI 370424	Yugoslavia	8.5	8.5	7.3	9.0	8.0	8.0	9.0
981	PI 370434	Yugoslavia	8.5	8.5	7.3	8.0	9.0	8.0	9.0
982	PI 378612	Zaire	8.5	8.5	7.3	8.0	9.0	9.0	8.0
983	PI 381728	India	8.5	8.5	7.3	9.0	8.0	8.0	9.0
984	PI 381740	India	8.5	8.5	7.3	8.0	9.0	8.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
985	PI 476327	Uzbekistan	8.5	8.5	7.3	9.0	8.0	9.0	8.0
986	PI 482289	Zimbabwe	8.5	8.5	7.3	8.0	8.0	9.0	9.0
987	PI 482297	Zimbabwe	8.5	8.5	7.3	8.0	9.0	9.0	8.0
988	PI 490379	Mali	8.5	8.5	7.3	8.0	8.0	9.0	9.0
989	PI 494815	Zambia	8.5	8.5	7.3	8.0	8.0	9.0	9.0
990	PI 512348	Spain	8.5	8.5	7.3	9.0	9.0	8.0	8.0
991	PI 518606	Russi	8.5	8.5	7.3	9.0	8.0	9.0	8.0
992	PI 526233	Zimbabwe	8.5	8.5	7.3	8.0	9.0	8.0	9.0
993	PI 534587	Syria	8.5	8.5	7.3	9.0	9.0	8.0	8.0
994	PI 537271	Pakistan	8.5	8.5	7.3	9.0	9.0	8.0	8.0
995	PI 629106	USA	8.5	8.5	7.3	9.0	9.0	8.0	8.0
996	PI 629109	USA	8.5	8.5	7.3	8.0	9.0	8.0	9.0
997	Golden	USA	8.5	8.5	7.3	9.0	8.0	8.0	9.0
998	PI 512388	Spain	8.5	8.5	7.3	9.0	8.0	8.0	9.0
999	PI 560018	Nigeria	8.5	8.5	7.3	9.0	8.0	9.0	8.0
1000	PI 368522	Yugoslavia	8.5	8.5	7.4	8.0	9.0	9.0	8.0
1001	PI 560001	Nigeria	8.5	8.5	7.4	8.0	9.0	9.0	8.0
1002	PI 379241	Yugoslavia	8.5	8.5	7.4	8.0	8.0	9.0	9.0
1003	PI 537472	Spain	8.5	8.5	7.4	8.0	9.0	8.0	9.0
1004	PI 368510	Yugoslavia	8.5	8.5	7.4	8.0	8.0	9.0	9.0
1005	PI 379255	Yugoslavia	8.5	8.5	7.4	9.0	9.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1006	PI 482314	Zimbabwe	8.5	8.5	7.4	9.0	8.0	8.0	9.0
1007	Grif 5602	India	8.5	8.5	7.4	9.0	8.0	8.0	9.0
1008	PI 163205	India	8.5	8.5	7.4	8.0	9.0	9.0	8.0
1009	PI 164633	India	8.5	8.5	7.4	8.0	9.0	9.0	8.0
1010	PI 164992	Turkey	8.5	8.5	7.4	8.0	9.0	8.0	9.0
1011	PI 165451	Mexico	8.5	8.5	7.4	8.0	9.0	8.0	9.0
1012	PI 165523	India	8.5	8.5	7.4	9.0	8.0	8.0	9.0
1013	PI 169271	Turkey	8.5	8.5	7.4	9.0	8.0	9.0	8.0
1014	PI 169281	Turkey	8.5	8.5	7.4	8.0	8.0	9.0	9.0
1015	PI 172798	Turkey	8.5	8.5	7.4	8.0	8.0	9.0	9.0
1016	PI 277975	Turkey	8.5	8.5	7.4	8.0	8.0	9.0	9.0
1017	PI 288317	India	8.5	8.5	7.4	8.0	9.0	8.0	9.0
1018	PI 296384	Iran	8.5	8.5	7.4	8.0	9.0	9.0	8.0
1019	PI 357708	Yugoslavia	8.5	8.5	7.4	8.0	9.0	8.0	9.0
1020	PI 357746	Yugoslavia	8.5	8.5	7.4	9.0	9.0	7.0	9.0
1021	PI 368526	Yugoslavia	8.5	8.5	7.4	9.0	9.0	8.0	8.0
1022	PI 369220	Soviet Union	8.5	8.5	7.4	9.0	9.0	8.0	8.0
1023	PI 370423	Yugoslavia	8.5	8.5	7.4	9.0	9.0	8.0	8.0
1024	PI 379249	Yugoslavia	8.5	8.5	7.4	8.0	9.0	9.0	8.0
1025	PI 482310	Zimbabwe	8.5	8.5	7.4	8.0	9.0	9.0	8.0
1026	PI 500317	Zambia	8.5	8.5	7.4	9.0	9.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1027	PI 512370	Spain	8.5	8.5	7.4	9.0	9.0	8.0	8.0
1028	PI 512384	Spain	8.5	8.5	7.4	9.0	9.0	8.0	8.0
1029	PI 512393	Spain	8.5	8.5	7.4	8.0	9.0	9.0	8.0
1030	PI 512405	Spain	8.5	8.5	7.4	9.0	9.0	8.0	8.0
1031	PI 525089	Egypt	8.5	8.5	7.4	8.0	8.0	9.0	9.0
1032	PI 526235	Zimbabwe	8.5	8.5	7.4	9.0	8.0	8.0	9.0
1033	PI 534535	Syria	8.5	8.5	7.4	8.0	9.0	9.0	8.0
1034	PI 534599	Syria	8.5	8.5	7.4	9.0	8.0	9.0	8.0
1035	PI 536452	Maldives	8.5	8.5	7.4	8.0	8.0	9.0	9.0
1036	PI 543211	Bolivia	8.5	8.5	7.4	8.0	9.0	9.0	8.0
1037	PI 549159	Mauritania	8.5	8.5	7.4	8.0	8.0	9.0	9.0
1038	PI 593364	China	8.5	8.5	7.4	8.0	9.0	8.0	9.0
1039	PI 600790	USA	8.5	8.5	7.4	8.0	8.0	9.0	9.0
1040	PI 612460	Korea	8.5	8.5	7.4	9.0	8.0	8.0	9.0
1041	PI 612463	Korea	8.5	8.5	7.4	8.0	9.0	8.0	9.0
1042	Peacock Shipper	USA	8.5	8.5	7.4	9.0	9.0	8.0	8.0
1043	PI 167059	Turkey	8.5	8.5	7.4	9.0	8.0	9.0	8.0
1044	PI 169258	Turkey	8.5	8.5	7.4	8.0	8.0	9.0	9.0
1045	PI 169266	Turkey	8.5	8.5	7.4	9.0	8.0	8.0	9.0
1046	PI 169268	Turkey	8.5	8.5	7.4	8.0	9.0	8.0	9.0
1047	PI 169299	Turkey	8.5	8.5	7.4	8.0	9.0	9.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1048	PI 172802	Turkey	8.5	8.5	7.4	8.0	9.0	9.0	8.0
1049	PI 175102	India	8.5	8.5	7.4	8.0	9.0	8.0	9.0
1050	PI 269464	Pakistan	8.5	8.5	7.4	9.0	9.0	8.0	8.0
1051	PI 357676	Yugoslavia	8.5	8.5	7.4	9.0	8.0	8.0	9.0
1052	PI 357677	Yugoslavia	8.5	8.5	7.4	9.0	9.0	8.0	8.0
1053	PI 357697	Yugoslavia	8.5	8.5	7.4	8.0	9.0	8.0	9.0
1054	PI 357698	Yugoslavia	8.5	8.5	7.4	9.0	9.0	8.0	8.0
1055	PI 357738	Yugoslavia	8.5	8.5	7.4	8.0	9.0	8.0	9.0
1056	PI 381701	India	8.5	8.5	7.4	8.0	9.0	9.0	8.0
1057	PI 381743	India	8.5	8.5	7.4	7.0	9.0	9.0	9.0
1058	PI 418762	Afghanistan	8.5	8.5	7.4	9.0	8.0	8.0	9.0
1059	PI 441722	Brazil	8.5	8.5	7.4	8.0	9.0	8.0	9.0
1060	PI 482350	Zimbabwe	8.5	8.5	7.4	8.0	9.0	8.0	9.0
1061	PI 500348	Zambia	8.5	8.5	7.4	9.0	9.0	8.0	8.0
1062	PI 534584	Syria	8.5	8.5	7.4	9.0	8.0	8.0	9.0
1063	PI 536459	Maldives	8.5	8.5	7.4	9.0	9.0	8.0	8.0
1064	PI 595218	USA	8.5	8.5	7.4	9.0	7.0	9.0	9.0
1065	PI 629104	Syria	8.5	8.5	7.4	8.0	8.0	9.0	9.0
1066	Sun Gold	USA	8.5	8.5	7.4	8.0	9.0	9.0	8.0
1067	PI 385964	Kenya	8.5	8.5	7.4	8.0	9.0	8.0	9.0
1068	PI 532813	China	8.5	8.5	7.5	9.0	8.0	8.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
1069	PI 179234	Turkey	8.5	8.5	7.5	8.0	8.0	9.0	9.0
1070	PI 357729	Yugoslavia	8.5	8.5	7.5	9.0	9.0	8.0	8.0
1071	Black Boy	USA	8.5	8.5	7.5	9.0	9.0	8.0	8.0
1072	Grif 1731	China	8.5	8.5	7.5	9.0	9.0	8.0	8.0
1073	PI 169243	Turkey	8.5	8.5	7.5	8.0	9.0	8.0	9.0
1074	PI 169265	Turkey	8.5	8.5	7.5	8.0	9.0	9.0	8.0
1075	PI 169286	Turkey	8.5	8.5	7.5	8.0	9.0	9.0	8.0
1076	PI 171582	Turkey	8.5	8.5	7.5	9.0	9.0	8.0	8.0
1077	PI 175655	Turkey	8.5	8.5	7.5	9.0	9.0	8.0	8.0
1078	PI 179880	India	8.5	8.5	7.5	8.0	9.0	9.0	8.0
1079	PI 250146	Pakistan	8.5	8.5	7.5	9.0	8.0	8.0	9.0
1080	PI 279458	Japan	8.5	8.5	7.5	9.0	9.0	8.0	8.0
1081	PI 314178	Soviet Union	8.5	8.5	7.5	8.0	9.0	9.0	8.0
1082	PI 378617	Zaire	8.5	8.5	7.5	9.0	8.0	9.0	8.0
1083	PI 379231	Yugoslavia	8.5	8.5	7.5	8.0	9.0	9.0	8.0
1084	PI 476325	Ukraine	8.5	8.5	7.5	9.0	9.0	8.0	8.0
1085	PI 482351	Zimbabwe	8.5	8.5	7.5	9.0	9.0	8.0	8.0
1086	PI 500314	Zambia	8.5	8.5	7.5	9.0	9.0	8.0	8.0
1087	PI 500341	Zambia	8.5	8.5	7.5	8.0	9.0	8.0	9.0
1088	PI 505584	Zambia	8.5	8.5	7.5	9.0	9.0	8.0	8.0
1089	PI 512347	Spain	8.5	8.5	7.5	9.0	9.0	8.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
1090	PI 512361	Spain	8.5	8.5	7.5	9.0	9.0	8.0	8.0
1091	PI 537270	Pakistan	8.5	8.5	7.5	9.0	9.0	8.0	8.0
1092	Early Arizona	USA	8.5	8.5	7.5	9.0	9.0	8.0	8.0
1093	PI 176493	Turkey	8.5	8.5	7.5	8.0	9.0	9.0	8.0
1094	PI 254623	Sudan	8.5	8.5	7.5	8.0	9.0	9.0	8.0
1095	PI 271133	Tunisia	8.5	8.5	7.5	8.0	9.0	9.0	8.0
1096	PI 271981	Somalia	8.5	8.5	7.5	8.0	8.0	9.0	9.0
1097	PI 306365	Taiwan	8.5	8.5	7.5	8.0	8.0	9.0	9.0
1098	PI 357681	Yugoslavia	8.5	8.5	7.5	9.0	8.0	8.0	9.0
1099	PI 381705	India	8.5	8.5	7.5	9.0	8.0	8.0	9.0
1100	PI 381750	India	8.5	8.5	7.5	8.0	8.0	9.0	9.0
1101	PI 476329	Soviet Union	8.5	8.5	7.5	9.0	9.0	8.0	8.0
1102	PI 500310	Zambia	8.5	8.5	7.5	8.0	8.0	9.0	9.0
1103	PI 500337	Zambia	8.5	8.5	7.5	9.0	8.0	8.0	9.0
1104	PI 505935	Zambia	8.5	8.5	7.5	8.0	9.0	9.0	8.0
1105	PI 593381	China	8.5	8.5	7.5	9.0	8.0	9.0	8.0
1106	PI 600951	USA	8.5	8.5	7.5	8.0	9.0	9.0	8.0
1107	PI 169283	Turkey	8.5	8.5	7.5	9.0	9.0	8.0	8.0
1108	PI 179882	India	8.5	8.5	7.5	8.0	9.0	8.0	9.0
1109	PI 216029	India	8.5	8.5	7.5	9.0	9.0	8.0	8.0
1110	PI 270548	Ghana	8.5	8.5	7.5	9.0	8.0	8.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1111	PI 368514	Yugoslavia	8.5	8.5	7.5	9.0	9.0	8.0	8.0
1112	PI 512354	Spain	8.5	8.5	7.5	8.0	9.0	9.0	8.0
1113	PI 512359	Spain	8.5	8.5	7.5	9.0	8.0	8.0	9.0
1114	PI 593366	China	8.5	8.5	7.5	8.0	9.0	8.0	9.0
1115	Sugarlee	USA	8.5	8.5	7.5	8.0	9.0	-	-
1116	Sweetheart	USA	8.5	8.5	7.5	9.0	-	8.0	-
1117	PI 525097	Egypt	8.5	8.5	7.5	9.0	9.0	7.0	9.0
1118	PI 171580	Turkey	8.5	8.5	7.5	7.0	9.0	9.0	9.0
1119	PI 277986	Turkey	8.5	8.5	7.5	8.0	9.0	8.0	9.0
1120	PI 278004	Turkey	8.5	8.5	7.5	9.0	8.0	8.0	9.0
1121	PI 344298	Turkey	8.5	8.5	7.5	8.0	8.0	9.0	9.0
1122	PI 357736	Yugoslavia	8.5	8.5	7.5	9.0	9.0	9.0	7.0
1123	PI 490376	Mali	8.5	8.5	7.5	8.0	8.0	9.0	9.0
1124	PI 500347	Zambia	8.5	8.5	7.5	8.0	9.0	8.0	9.0
1125	PI 512366	Spain	8.5	8.5	7.5	8.0	8.0	9.0	9.0
1126	PI 512828	Spain	8.5	8.5	7.5	9.0	8.0	8.0	9.0
1127	PI 612474	Korea	8.5	8.5	7.5	8.0	9.0	8.0	9.0
1128	PI 227206	Japan	8.5	8.5	7.5	9.0	9.0	9.0	7.0
1129	PI 169287	Turkey	8.5	8.5	7.6	9.0	9.0	8.0	8.0
1130	PI 172795	Turkey	8.5	8.5	7.6	9.0	8.0	9.0	8.0
1131	PI 368508	Yugoslavia	8.5	8.5	7.6	8.0	9.0	8.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
1132	PI 482352	Zimbabwe	8.5	8.5	7.6	8.0	8.0	9.0	9.0
1133	PI 500301	Zambia	8.5	8.5	7.6	7.0	9.0	9.0	9.0
1134	PI 534594	Syria	8.5	8.5	7.6	9.0	8.0	8.0	9.0
1135	PI 537299	Uzbekistan	8.5	8.5	7.6	8.0	9.0	9.0	8.0
1136	Moon&Str	USA	8.5	8.5	7.6	9.0	8.0	8.0	9.0
1137	PI 253174	Yugoslavia	8.5	8.5	7.6	9.0	9.0	8.0	8.0
1138	PI 273479	Ethiopia	8.5	8.5	7.6	8.0	9.0	9.0	8.0
1139	PI 368494	Yugoslavia	8.5	8.5	7.6	8.0	9.0	8.0	9.0
1140	PI 507867	Hungary	8.5	8.5	7.6	9.0	9.0	8.0	8.0
1141	PI 536449	Maldives	8.5	8.5	7.6	9.0	9.0	8.0	8.0
1142	PI 629108	USA	8.5	8.5	7.6	9.0	9.0	8.0	8.0
1143	PI 169295	Turkey	8.5	8.5	7.6	9.0	9.0	8.0	8.0
1144	PI 278013	Turkey	8.5	8.5	7.6	9.0	9.0	8.0	8.0
1145	PI 278029	Turkey	8.5	8.5	7.6	8.0	9.0	8.0	9.0
1146	PI 379227	Yugoslavia	8.5	8.5	7.6	8.0	8.0	9.0	9.0
1147	PI 494819	Zambia	8.5	8.5	7.6	8.0	8.0	9.0	9.0
1148	PI 500349	Zambia	8.5	8.5	7.6	8.0	9.0	8.0	9.0
1149	PI 176489	Turkey	8.5	8.5	7.6	8.0	8.0	9.0	9.0
1150	PI 381699	India	8.5	8.5	7.6	8.0	9.0	8.0	9.0
1151	PI 277973	Turkey	8.5	8.5	7.6	8.0	8.0	9.0	9.0
1152	PI 357721	Yugoslavia	8.5	8.5	7.6	9.0	7.0	9.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1153	PI 534534	Syria	8.5	8.5	7.6	9.0	8.0	8.0	9.0
1154	PI 163204	India	8.5	8.5	7.6	9.0	8.0	8.0	9.0
1155	PI 169253	Turkey	8.5	8.5	7.6	8.0	8.0	9.0	9.0
1156	PI 169300	Turkey	8.5	8.5	7.6	9.0	8.0	8.0	9.0
1157	PI 251796	Yugoslavia	8.5	8.5	7.6	8.0	9.0	8.0	9.0
1158	PI 270547	Ghana	8.5	8.5	7.6	9.0	8.0	8.0	9.0
1159	PI 357747	Yugoslavia	8.5	8.5	7.6	8.0	8.0	9.0	9.0
1160	PI 525086	Egypt	8.5	8.5	7.6	9.0	8.0	8.0	9.0
1161	PI 536453	Maldives	8.5	8.5	7.6	8.0	8.0	9.0	9.0
1162	PI 537465	Spain	8.5	8.5	7.6	8.0	8.0	9.0	9.0
1163	PI 593371	China	8.5	8.5	7.6	8.0	8.0	9.0	9.0
1164	Picnic	USA	8.5	8.5	7.6	9.0	8.0	8.0	9.0
1165	PI 195771	Guatemala	8.5	8.5	7.6	9.0	8.0	8.0	9.0
1166	PI 207472	Afghanistan	8.5	8.5	7.6	9.0	8.0	8.0	9.0
1167	PI 221430	Iran	8.5	8.5	7.6	8.0	9.0	8.0	9.0
1168	PI 314655	Soviet Union	8.5	8.5	7.6	7.0	9.0	9.0	9.0
1169	PI 174101	Turkey	8.5	8.5	7.7	8.0	9.0	8.0	9.0
1170	PI 222778	Iran	8.5	8.5	7.7	9.0	9.0	8.0	8.0
1171	PI 381722	India	8.5	8.5	7.7	9.0	9.0	8.0	8.0
1172	PI 277984	Turkey	8.5	8.5	7.7	8.0	9.0	8.0	9.0
1173	PI 536458	Maldives	8.5	8.5	7.7	8.0	9.0	8.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
1174	PI 254429	Lebanon	8.5	8.5	7.7	8.0	-	-	9.0
1175	PI 368493	Yugoslavia	8.5	8.5	7.7	8.0	8.0	9.0	9.0
1176	PI 368521	Yugoslavia	8.5	8.5	7.7	8.0	9.0	9.0	8.0
1177	PI 381704	India	8.5	8.5	7.7	7.0	9.0	9.0	9.0
1178	PI 532817	China	8.5	8.5	7.7	8.0	9.0	8.0	9.0
1179	Black Diamond YB	USA	8.5	8.5	7.7	-	-	9.0	8.0
1180	PI 175662	Turkey	8.5	8.5	7.7	9.0	9.0	8.0	8.0
1181	PI 306366	Taiwan	8.5	8.5	7.7	9.0	8.0	8.0	9.0
1182	PI 357720	Yugoslavia	8.5	8.5	7.7	9.0	8.0	8.0	9.0
1183	PI 435282	Iraq	8.5	8.5	7.7	9.0	9.0	7.0	9.0
1184	PI 169254	Turkey	8.5	8.5	7.7	9.0	8.0	8.0	9.0
1185	PI 234287	Portugal	8.5	8.5	7.7	9.0	8.0	8.0	9.0
1186	PI 368516	Yugoslavia	8.5	8.5	7.7	8.0	8.0	9.0	9.0
1187	PI 172787	Turkey	8.5	8.5	7.7	8.0	8.0	9.0	9.0
1188	PI 175660	Turkey	8.5	8.5	7.7	9.0	8.0	8.0	9.0
1189	PI 379236	Yugoslavia	8.5	8.5	7.7	9.0	8.0	8.0	9.0
1190	PI 271466	India	8.5	8.5	7.8	9.0	9.0	8.0	8.0
1191	PI 183126	India	8.5	8.5	7.8	8.0	9.0	8.0	9.0
1192	PI 279462	Japan	8.5	8.5	7.8	9.0	9.0	8.0	8.0
1193	PI 438673	Mexico	8.5	8.5	7.8	9.0	9.0	8.0	8.0
1194	PI 164708	India	8.5	8.5	7.8	9.0	8.0	8.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
1195	PI 169270	Turkey	8.5	8.5	7.8	8.0	9.0	9.0	8.0
1196	PI 173888	India	8.5	8.5	7.8	8.0	9.0	8.0	9.0
1197	PI 228237	Israel	8.5	8.5	7.8	9.0	8.0	9.0	8.0
1198	PI 249559	Thailand	8.5	8.5	7.8	7.0	9.0	9.0	9.0
1199	PI 512378	Spain	8.5	8.5	7.8	9.0	9.0	8.0	8.0
1200	PI 537461	Spain	8.5	8.5	7.8	8.0	8.0	9.0	9.0
1201	PI 537470	Spain	8.5	8.5	7.8	9.0	9.0	8.0	8.0
1202	PI 179883	India	8.5	8.5	7.8	9.0	9.0	8.0	8.0
1203	PI 195928	Ethiopia	8.5	8.5	7.8	8.0	8.0	9.0	9.0
1204	PI 357742	Yugoslavia	8.5	8.5	7.8	8.0	8.0	9.0	9.0
1205	PI 175652	Turkey	8.5	8.5	7.8	9.0	9.0	9.0	7.0
1206	PI 370430	Yugoslavia	8.5	8.5	7.8	8.0	8.0	9.0	9.0
1207	PI 278041	Turkey	8.5	8.5	7.8	9.0	9.0	8.0	8.0
1208	PI 357717	Yugoslavia	8.5	8.5	7.8	8.0	9.0	9.0	8.0
1209	PI 368497	Yugoslavia	8.5	8.5	7.8	8.0	9.0	8.0	9.0
1210	PI 525085	Egypt	8.5	8.5	7.8	8.0	9.0	8.0	9.0
1211	PI 169264	Turkey	8.5	8.5	7.8	8.0	9.0	8.0	9.0
1212	PI 438675	Mexico	8.5	8.5	7.8	8.0	9.0	9.0	8.0
1213	PI 183398	India	8.5	8.5	7.8	9.0	8.0	8.0	9.0
1214	PI 612145	USA	8.5	8.5	7.8	8.0	9.0	8.0	9.0
1215	PI 240532	Iran	8.5	8.5	7.9	8.0	9.0	9.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
1216	PI 379248	Yugoslavia	8.5	8.5	7.9	9.0	9.0	8.0	8.0
1217	PI 379232	Yugoslavia	8.5	8.5	7.9	9.0	9.0	8.0	8.0
1218	PI 507860	Hungary	8.5	8.5	7.9	8.0	8.0	9.0	9.0
1219	PI 223765	Afghanistan	8.5	8.5	8.0	9.0	8.0	9.0	8.0
1220	PI 270141	India	8.5	8.5	8.0	-	9.0	-	8.0
1221	PI 182932	India	8.5	8.5	8.0	8.0	-	-	9.0
1222	Grif 5601	India	8.5	8.5	8.2	8.0	-	-	9.0
1223	PI 169288	Turkey	8.5	8.5	8.2	9.0	8.0	8.0	9.0
1224	PI 269365	Afghanistan	8.5	8.5	8.3	-	9.0	8.0	-
1225	PI 532668	Zimbabwe	8.7	8.7	7.3	9.0	8.0	9.0	-
1226	PI 600792	USA	8.7	8.7	7.4	9.0	8.0	-	9.0
1227	PI 357730	Yugoslavia	8.7	8.7	7.6	8.0	9.0	9.0	-
1228	PI 181742	Lebanon	8.7	8.7	7.6	9.0	-	8.0	9.0
1229	PI 278037	Turkey	8.7	8.7	7.6	8.0	-	9.0	9.0
1230	PI 512404	Spain	8.7	8.7	7.6	9.0	-	9.0	8.0
1231	PI 357663	Yugoslavia	8.7	8.7	7.7	9.0	9.0	8.0	-
1232	PI 171583	Turkey	8.7	8.7	7.7	-	8.0	9.0	9.0
1233	PI 179241	Iraq	8.7	8.7	7.7	9.0	9.0	-	8.0
1234	PI 357671	Yugoslavia	8.7	8.7	7.7	9.0	-	8.0	9.0
1235	PI 512369	Spain	8.7	8.7	7.7	8.0	9.0	9.0	-
1236	PI 166993	Turkey	8.7	8.7	7.7	8.0	-	9.0	9.0

(continued next page)

Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1237	PI 271986	Somalia	8.7	8.7	7.9	9.0	8.0	9.0	-
1238	PI 177330	Syria	8.7	8.7	8.0	9.0	9.0	-	8.0
1239	PI 295848	S. Africa	8.8	8.8	7.2	9.0	9.0	9.0	8.0
1240	PI 379237	Yugoslavia	8.8	8.8	7.2	9.0	9.0	9.0	8.0
1241	PI 512381	Spain	8.8	8.8	7.2	9.0	8.0	9.0	9.0
1242	PI 593360	China	8.8	8.8	7.3	9.0	9.0	8.0	9.0
1243	PI 512363	Spain	8.8	8.8	7.3	9.0	9.0	8.0	9.0
1244	PI 195562	Ethiopia	8.8	8.8	7.3	9.0	9.0	8.0	9.0
1245	PI 368511	Yugoslavia	8.8	8.8	7.3	9.0	9.0	9.0	8.0
1246	PI 379235	Yugoslavia	8.8	8.8	7.3	9.0	8.0	9.0	9.0
1247	PI 482267	Zimbabwe	8.8	8.8	7.3	8.0	9.0	9.0	9.0
1248	PI 487459	Venezuela	8.8	8.8	7.3	9.0	9.0	8.0	9.0
1249	PI 507865	Hungary	8.8	8.8	7.3	9.0	9.0	9.0	8.0
1250	PI 525082	Egypt	8.8	8.8	7.3	9.0	8.0	9.0	9.0
1251	PI 534593	Syria	8.8	8.8	7.3	8.0	9.0	9.0	9.0
1252	PI 612459	Korea	8.8	8.8	7.3	8.0	9.0	9.0	9.0
1253	PI 629102	USA	8.8	8.8	7.3	8.0	9.0	9.0	9.0
1254	Chubby Gray	USA	8.8	8.8	7.3	9.0	9.0	8.0	9.0
1255	PI 279460	Japan	8.8	8.8	7.3	9.0	8.0	9.0	9.0
1256	PI 512344	Spain	8.8	8.8	7.3	8.0	9.0	9.0	9.0
1257	PI 593377	China	8.8	8.8	7.3	8.0	9.0	9.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1258	PI 512343	Spain	8.8	8.8	7.3	9.0	9.0	9.0	8.0
1259	PI 490384	Mali	8.8	8.8	7.3	9.0	9.0	8.0	9.0
1260	PI 379239	Yugoslavia	8.8	8.8	7.4	9.0	8.0	9.0	9.0
1261	PI 525093	Egypt	8.8	8.8	7.4	9.0	9.0	8.0	9.0
1262	PI 278053	Turkey	8.8	8.8	7.4	9.0	9.0	8.0	9.0
1263	PI 357714	Yugoslavia	8.8	8.8	7.4	8.0	9.0	9.0	9.0
1264	PI 163203	India	8.8	8.8	7.4	9.0	9.0	9.0	8.0
1265	PI 169236	Turkey	8.8	8.8	7.4	8.0	9.0	9.0	9.0
1266	PI 169237	Turkey	8.8	8.8	7.4	9.0	9.0	9.0	8.0
1267	PI 181744	Lebanon	8.8	8.8	7.4	9.0	8.0	9.0	9.0
1268	PI 229605	Iran	8.8	8.8	7.4	9.0	9.0	9.0	8.0
1269	PI 229748	Iran	8.8	8.8	7.4	9.0	9.0	9.0	8.0
1270	PI 277978	Turkey	8.8	8.8	7.4	8.0	9.0	9.0	9.0
1271	PI 278006	Turkey	8.8	8.8	7.4	9.0	8.0	9.0	9.0
1272	PI 357703	Yugoslavia	8.8	8.8	7.4	8.0	9.0	9.0	9.0
1273	PI 357704	Yugoslavia	8.8	8.8	7.4	8.0	9.0	9.0	9.0
1274	PI 357732	Yugoslavia	8.8	8.8	7.4	9.0	8.0	9.0	9.0
1275	PI 368501	Yugoslavia	8.8	8.8	7.4	9.0	8.0	9.0	9.0
1276	PI 379253	Yugoslavia	8.8	8.8	7.4	9.0	9.0	8.0	9.0
1277	PI 381731	India	8.8	8.8	7.4	9.0	8.0	9.0	9.0
1278	PI 464872	China	8.8	8.8	7.4	9.0	9.0	8.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1279	PI 470248	Indonesia	8.8	8.8	7.4	9.0	9.0	9.0	8.0
1280	PI 476330	Soviet Union	8.8	8.8	7.4	9.0	8.0	9.0	9.0
1281	PI 512392	Spain	8.8	8.8	7.4	9.0	8.0	9.0	9.0
1282	PI 593351	China	8.8	8.8	7.4	8.0	9.0	9.0	9.0
1283	PI 612470	Korea	8.8	8.8	7.4	9.0	8.0	9.0	9.0
1284	PI 223764	Afghanistan	8.8	8.8	7.4	8.0	9.0	9.0	9.0
1285	PI 277996	Turkey	8.8	8.8	7.4	9.0	8.0	9.0	9.0
1286	PI 512390	Spain	8.8	8.8	7.4	8.0	9.0	9.0	9.0
1287	PI 593357	China	8.8	8.8	7.4	9.0	9.0	9.0	8.0
1288	PI 612473	Korea	8.8	8.8	7.4	9.0	8.0	9.0	9.0
1289	PI 357673	Yugoslavia	8.8	8.8	7.5	9.0	9.0	8.0	9.0
1290	PI 438671	Mexico	8.8	8.8	7.5	8.0	9.0	9.0	9.0
1291	PI 175653	Turkey	8.8	8.8	7.5	9.0	9.0	8.0	9.0
1292	PI 279459	Japan	8.8	8.8	7.5	9.0	8.0	9.0	9.0
1293	PI 326515	Ghana	8.8	8.8	7.5	9.0	9.0	8.0	9.0
1294	PI 357679	Yugoslavia	8.8	8.8	7.5	9.0	9.0	9.0	8.0
1295	PI 357683	Yugoslavia	8.8	8.8	7.5	8.0	9.0	9.0	9.0
1296	PI 357731	Yugoslavia	8.8	8.8	7.5	8.0	9.0	9.0	9.0
1297	PI 368498	Yugoslavia	8.8	8.8	7.5	9.0	9.0	9.0	8.0
1298	PI 368505	Yugoslavia	8.8	8.8	7.5	9.0	9.0	9.0	8.0
1299	PI 368519	Yugoslavia	8.8	8.8	7.5	8.0	9.0	9.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1300	PI 415095	Honduras	8.8	8.8	7.5	9.0	8.0	9.0	9.0
1301	PI 482278	Zimbabwe	8.8	8.8	7.5	9.0	8.0	9.0	9.0
1302	PI 482370	Zimbabwe	8.8	8.8	7.5	8.0	9.0	9.0	9.0
1303	PI 507864	Hungary	8.8	8.8	7.5	8.0	9.0	9.0	9.0
1304	PI 561122	China	8.8	8.8	7.5	9.0	9.0	9.0	8.0
1305	PI 176486	Turkey	8.8	8.8	7.5	9.0	9.0	9.0	8.0
1306	PI 176911	Turkey	8.8	8.8	7.5	9.0	9.0	8.0	9.0
1307	PI 177318	Turkey	8.8	8.8	7.5	8.0	9.0	9.0	9.0
1308	PI 344301	Turkey	8.8	8.8	7.5	9.0	9.0	8.0	9.0
1309	PI 357743	Yugoslavia	8.8	8.8	7.5	9.0	9.0	8.0	9.0
1310	PI 370432	Yugoslavia	8.8	8.8	7.5	8.0	9.0	9.0	9.0
1311	PI 502316	Uzbekistan	8.8	8.8	7.5	9.0	9.0	8.0	9.0
1312	PI 512398	Spain	8.8	8.8	7.5	9.0	9.0	9.0	8.0
1313	PI 512406	Spain	8.8	8.8	7.5	9.0	8.0	9.0	9.0
1314	PI 537265	Pakistan	8.8	8.8	7.5	9.0	9.0	9.0	8.0
1315	PI 593379	China	8.8	8.8	7.5	9.0	9.0	9.0	8.0
1316	PI 593380	China	8.8	8.8	7.5	9.0	9.0	8.0	9.0
1317	PI 482340	Zimbabwe	8.8	8.8	7.5	8.0	9.0	9.0	9.0
1318	PI 293765	Soviet Union	8.8	8.8	7.5	9.0	9.0	8.0	9.0
1319	PI 357665	Yugoslavia	8.8	8.8	7.5	9.0	9.0	8.0	9.0
1320	PI 368504	Yugoslavia	8.8	8.8	7.5	8.0	9.0	9.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1321	PI 505588	Zambia	8.8	8.8	7.5	8.0	9.0	9.0	9.0
1322	PI 512395	Spain	8.8	8.8	7.5	8.0	9.0	9.0	9.0
1323	PI 612475	Korea	8.8	8.8	7.5	9.0	8.0	9.0	9.0
1324	PI 381696	India	8.8	8.8	7.5	9.0	9.0	9.0	8.0
1325	PI 290855	USA	8.8	8.8	7.6	9.0	9.0	8.0	9.0
1326	PI 379223	Yugoslavia	8.8	8.8	7.6	9.0	9.0	8.0	9.0
1327	PI 482362	Zimbabwe	8.8	8.8	7.6	8.0	9.0	9.0	9.0
1328	PI 169256	Turkey	8.8	8.8	7.6	9.0	9.0	9.0	8.0
1329	PI 357754	Yugoslavia	8.8	8.8	7.6	9.0	9.0	9.0	8.0
1330	PI 381725	India	8.8	8.8	7.6	8.0	9.0	9.0	9.0
1331	PI 507859	Hungary	8.8	8.8	7.6	9.0	9.0	9.0	8.0
1332	PI 470249	Indonesia	8.8	8.8	7.6	9.0	8.0	9.0	9.0
1333	PI 165024	Turkey	8.8	8.8	7.6	9.0	8.0	9.0	9.0
1334	PI 177323	Turkey	8.8	8.8	7.6	9.0	9.0	8.0	9.0
1335	PI 278010	Turkey	8.8	8.8	7.6	9.0	9.0	9.0	8.0
1336	PI 357688	Yugoslavia	8.8	8.8	7.6	9.0	9.0	9.0	8.0
1337	PI 357694	Yugoslavia	8.8	8.8	7.6	9.0	9.0	9.0	8.0
1338	PI 357695	Yugoslavia	8.8	8.8	7.6	8.0	9.0	9.0	9.0
1339	PI 368520	Yugoslavia	8.8	8.8	7.6	9.0	9.0	9.0	8.0
1340	PI 420320	Italy	8.8	8.8	7.6	9.0	9.0	9.0	8.0
1341	PI 475746	Paraguay	8.8	8.8	7.6	9.0	9.0	9.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1342	PI 482368	Zimbabwe	8.8	8.8	7.6	9.0	9.0	9.0	8.0
1343	PI 491265	Zimbabwe	8.8	8.8	7.6	9.0	9.0	8.0	9.0
1344	PI 507858	Hungary	8.8	8.8	7.6	9.0	9.0	9.0	8.0
1345	PI 512374	Spain	8.8	8.8	7.6	9.0	9.0	9.0	8.0
1346	PI 512386	Spain	8.8	8.8	7.6	9.0	9.0	8.0	9.0
1347	PI 593386	China	8.8	8.8	7.6	8.0	9.0	9.0	9.0
1348	PI 169239	Turkey	8.8	8.8	7.6	9.0	9.0	8.0	9.0
1349	PI 179236	Turkey	8.8	8.8	7.6	8.0	9.0	9.0	9.0
1350	PI 271747	Afghanistan	8.8	8.8	7.6	9.0	9.0	8.0	9.0
1351	PI 357664	Yuogslavia	8.8	8.8	7.6	8.0	9.0	9.0	9.0
1352	PI 357693	Yugoslavia	8.8	8.8	7.6	9.0	8.0	9.0	9.0
1353	PI 357723	Yugoslavia	8.8	8.8	7.6	9.0	9.0	9.0	8.0
1354	PI 458738	Paraguay	8.8	8.8	7.6	9.0	9.0	9.0	8.0
1355	PI 502317	Uzbekistan	8.8	8.8	7.6	8.0	9.0	9.0	9.0
1356	PI 512365	Spain	8.8	8.8	7.6	8.0	9.0	9.0	9.0
1357	PI 525100	Italy	8.8	8.8	7.6	9.0	8.0	9.0	9.0
1358	PI 534592	Syria	8.8	8.8	7.6	9.0	9.0	8.0	9.0
1359	PI 169250	Turkey	8.8	8.8	7.7	9.0	9.0	9.0	8.0
1360	PI 254428	Lebanon	8.8	8.8	7.7	8.0	9.0	9.0	9.0
1361	Grif 5599	India	8.8	8.8	7.7	9.0	9.0	8.0	9.0
1362	PI 277989	Turkey	8.8	8.8	7.7	9.0	9.0	9.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1363	PI 556995	USA	8.8	8.8	7.7	9.0	9.0	9.0	8.0
1364	Super Sweet	USA	8.8	8.8	7.7	9.0	9.0	8.0	9.0
1365	PI 175659	Turkey	8.8	8.8	7.7	9.0	9.0	9.0	8.0
1366	PI 435085	China	8.8	8.8	7.7	9.0	9.0	8.0	9.0
1367	PI 543209	Bolivia	8.8	8.8	7.7	9.0	8.0	9.0	9.0
1368	PI 164687	India	8.8	8.8	7.7	9.0	8.0	9.0	9.0
1369	PI 277976	Turkey	8.8	8.8	7.7	9.0	9.0	8.0	9.0
1370	PI 278026	Turkey	8.8	8.8	7.7	9.0	9.0	9.0	8.0
1371	PI 278028	Turkey	8.8	8.8	7.7	8.0	9.0	9.0	9.0
1372	PI 278030	Turkey	8.8	8.8	7.7	8.0	9.0	9.0	9.0
1373	PI 357691	Yugoslavia	8.8	8.8	7.7	9.0	9.0	9.0	8.0
1374	PI 368529	Yugoslavia	8.8	8.8	7.7	9.0	9.0	8.0	9.0
1375	PI 507866	Hungary	8.8	8.8	7.7	9.0	9.0	9.0	8.0
1376	PI 512351	Spain	8.8	8.8	7.7	9.0	9.0	9.0	8.0
1377	PI 525091	Egypt	8.8	8.8	7.7	8.0	9.0	9.0	9.0
1378	PI 537467	Spain	8.8	8.8	7.7	9.0	8.0	9.0	9.0
1379	PI 612457	Korea	8.8	8.8	7.7	9.0	9.0	9.0	8.0
1380	PI 612465	Korea	8.8	8.8	7.7	9.0	8.0	9.0	9.0
1381	PI 629101	China	8.8	8.8	7.7	9.0	9.0	8.0	9.0
1382	PI 169238	Turkey	8.8	8.8	7.7	8.0	9.0	9.0	9.0
1383	PI 176487	Turkey	8.8	8.8	7.7	9.0	9.0	9.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1384	PI 176923	Turkey	8.8	8.8	7.7	9.0	9.0	9.0	8.0
1385	PI 212288	Afghanistan	8.8	8.8	7.7	8.0	9.0	9.0	9.0
1386	PI 277977	Turkey	8.8	8.8	7.7	8.0	9.0	9.0	9.0
1387	PI 278000	Turkey	8.8	8.8	7.7	8.0	9.0	9.0	9.0
1388	PI 278021	Turkey	8.8	8.8	7.7	9.0	9.0	8.0	9.0
1389	PI 331106	Uruguay	8.8	8.8	7.7	8.0	9.0	9.0	9.0
1390	PI 357726	Yugoslavia	8.8	8.8	7.7	8.0	9.0	9.0	9.0
1391	PI 379242	Yugoslavia	8.8	8.8	7.7	9.0	9.0	8.0	9.0
1392	PI 381700	India	8.8	8.8	7.7	8.0	9.0	9.0	9.0
1393	PI 500320	Zambia	8.8	8.8	7.7	9.0	9.0	9.0	8.0
1394	PI 519612	Soviet Union	8.8	8.8	7.7	8.0	9.0	9.0	9.0
1395	PI 532818	China	8.8	8.8	7.7	9.0	9.0	9.0	8.0
1396	PI 556994	USA	8.8	8.8	7.7	9.0	9.0	8.0	9.0
1397	PI 608047	USA	8.8	8.8	7.7	8.0	9.0	9.0	9.0
1398	PI 612471	Korea	8.8	8.8	7.7	9.0	9.0	9.0	8.0
1399	PI 169285	Turkey	8.8	8.8	7.7	8.0	9.0	9.0	9.0
1400	PI 176912	Turkey	8.8	8.8	7.7	9.0	9.0	8.0	9.0
1401	PI 357657	Yugoslavia	8.8	8.8	7.7	8.0	9.0	9.0	9.0
1402	PI 357748	Yugoslavia	8.8	8.8	7.7	9.0	9.0	8.0	9.0
1403	PI 512368	Spain	8.8	8.8	7.7	9.0	8.0	9.0	9.0
1404	PI 525084	Egypt	8.8	8.8	7.7	8.0	9.0	9.0	9.0

(continued next page)

Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
1405	PI 357713	Yugoslavia	8.8	8.8	7.7	9.0	9.0	8.0	9.0
1406	PI 357753	Yugoslavia	8.8	8.8	7.7	9.0	8.0	9.0	9.0
1407	PI 379254	Yugoslavia	8.8	8.8	7.7	9.0	9.0	8.0	9.0
1408	PI 506439	Moldova	8.8	8.8	7.7	8.0	9.0	9.0	9.0
1409	PI 534532	Syria	8.8	8.8	7.7	9.0	9.0	8.0	9.0
1410	PI 164655	India	8.8	8.8	7.8	9.0	8.0	9.0	9.0
1411	PI 169255	Turkey	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1412	Champion	USA	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1413	PI 270306	Philippines	8.8	8.8	7.8	9.0	9.0	9.0	8.0
1414	PI 176905	Turkey	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1415	PI 277279	India	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1416	PI 277971	Turkey	8.8	8.8	7.8	9.0	9.0	9.0	8.0
1417	PI 344395	Iran	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1418	PI 512332	China	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1419	PI 512382	Spain	8.8	8.8	7.8	9.0	9.0	9.0	8.0
1420	PI 540911	Unknown	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1421	Princeton	USA	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1422	PI 164748	India	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1423	PI 176909	Turkey	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1424	PI 176922	Turkey	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1425	PI 177320	Turkey	8.8	8.8	7.8	9.0	9.0	9.0	8.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1426	PI 177322	Turkey	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1427	PI 179885	India	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1428	PI 182177	Turkey	8.8	8.8	7.8	9.0	9.0	9.0	8.0
1429	PI 278032	Turkey	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1430	PI 346787	USA	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1431	PI 381718	India	8.8	8.8	7.8	9.0	9.0	9.0	8.0
1432	PI 487458	Venezuela	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1433	PI 512396	Spain	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1434	PI 525096	Egypt	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1435	PI 629105	USA	8.8	8.8	7.8	9.0	9.0	9.0	8.0
1436	Crimson Sweet	USA	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1437	PI 295845	S. Africa	8.8	8.8	7.8	9.0	8.0	9.0	9.0
1438	PI 368507	Yugoslavia	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1439	PI 370433	Yugoslavia	8.8	8.8	7.8	9.0	9.0	9.0	8.0
1440	PI 381723	India	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1441	PI 381733	India	8.8	8.8	7.8	9.0	8.0	9.0	9.0
1442	PI 500309	Zambia	8.8	8.8	7.8	9.0	9.0	9.0	8.0
1443	PI 512362	Spain	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1444	PI 536454	Maldives	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1445	PI 381753	India	8.8	8.8	7.8	9.0	9.0	9.0	8.0
1446	PI 431579	India	8.8	8.8	7.8	8.0	9.0	9.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1447	PI 512340	Spain	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1448	PI 278040	Turkey	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1449	PI 525087	Egypt	8.8	8.8	7.8	9.0	8.0	9.0	9.0
1450	PI 164709	India	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1451	PI 171584	Turkey	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1452	PI 176499	Turkey	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1453	PI 500302	Zambia	8.8	8.8	7.8	9.0	9.0	9.0	8.0
1454	PI 500346	Zambia	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1455	PI 180275	India	8.8	8.8	7.8	9.0	9.0	9.0	8.0
1456	PI 176916	Turkey	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1457	PI 277972	Turkey	8.8	8.8	7.8	9.0	9.0	9.0	8.0
1458	PI 278005	Turkey	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1459	PI 278014	Turkey	8.8	8.8	7.8	9.0	9.0	9.0	8.0
1460	PI 278019	Turkey	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1461	PI 278052	Turkey	8.8	8.8	7.8	9.0	8.0	9.0	9.0
1462	PI 370018	India	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1463	PI 164636	India	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1464	PI 179884	India	8.8	8.8	7.8	9.0	8.0	9.0	9.0
1465	PI 271363	India	8.8	8.8	7.8	9.0	8.0	9.0	9.0
1466	PI 357662	Yugoslavia	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1467	PI 379225	Yugoslavia	8.8	8.8	7.8	8.0	9.0	9.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1468	PI 479704	USA	8.8	8.8	7.8	9.0	9.0	8.0	9.0
1469	PI 507869	Hungary	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1470	PI 512355	Spain	8.8	8.8	7.8	8.0	9.0	9.0	9.0
1471	PI 536451	Maldives	8.8	8.8	7.8	9.0	8.0	9.0	9.0
1472	PI 536460	Maldives	8.8	8.8	7.8	9.0	8.0	9.0	9.0
1473	PI 381734	India	8.8	8.8	7.9	9.0	9.0	8.0	9.0
1474	PI 381741	India	8.8	8.8	7.9	9.0	9.0	8.0	9.0
1475	PI 449332	India	8.8	8.8	7.9	8.0	9.0	9.0	9.0
1476	PI 512407	Spain	8.8	8.8	7.9	9.0	9.0	8.0	9.0
1477	PI 226634	Iran	8.8	8.8	7.9	9.0	9.0	9.0	8.0
1478	PI 169251	Turkey	8.8	8.8	7.9	9.0	9.0	9.0	8.0
1479	PI 172789	Turkey	8.8	8.8	7.9	9.0	9.0	9.0	8.0
1480	PI 629107	USA	8.8	8.8	7.9	9.0	9.0	8.0	9.0
1481	PI 169246	Turkey	8.8	8.8	7.9	8.0	9.0	9.0	9.0
1482	PI 169249	Turkey	8.8	8.8	7.9	9.0	8.0	9.0	9.0
1483	PI 212983	India	8.8	8.8	7.9	9.0	9.0	9.0	8.0
1484	PI 277985	Turkey	8.8	8.8	7.9	9.0	9.0	9.0	8.0
1485	PI 381737	India	8.8	8.8	7.9	8.0	9.0	9.0	9.0
1486	PI 164146	India	8.8	8.8	8.0	9.0	9.0	8.0	9.0
1487	PI 368518	Yugoslavia	8.8	8.8	8.0	8.0	9.0	9.0	9.0
1488	PI 177328	Turkey	8.8	8.8	8.0	9.0	9.0	8.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1489	PI 193964	Ethiopia	8.8	8.8	8.0	8.0	9.0	9.0	9.0
1490	PI 212596	Afghanistan	8.8	8.8	8.0	9.0	8.0	9.0	9.0
1491	PI 182175	Turkey	8.8	8.8	8.0	9.0	9.0	9.0	8.0
1492	PI 182179	Turkey	8.8	8.8	8.0	8.0	9.0	9.0	9.0
1493	PI 512371	Spain	8.8	8.8	8.0	9.0	9.0	9.0	8.0
1494	PI 536455	Maldives	8.8	8.8	8.0	8.0	9.0	9.0	9.0
1495	PI 278024	Turkey	8.8	8.8	8.1	8.0	9.0	9.0	9.0
1496	PI 537473	Spain	8.8	8.8	8.1	9.0	8.0	9.0	9.0
1497	PI 277990	Turkey	8.8	8.8	8.2	9.0	9.0	8.0	9.0
1498	PI 540917	Unknown	8.8	8.8	8.2	9.0	9.0	8.0	9.0
1499	PI 172801	Turkey	8.8	8.8	8.2	9.0	8.0	9.0	9.0
1500	PI 536461	Maldives	8.8	8.8	8.2	9.0	8.0	9.0	9.0
1501	PI 179662	India	8.8	8.8	8.3	8.0	9.0	9.0	9.0
1502	PI 270523	Israel	8.8	8.8	8.5	9.0	9.0	9.0	8.0
1503	PI 175654	Turkey	9.0	9.0	7.4	9.0	9.0	9.0	-
1504	PI 378613	Zaire	9.0	9.0	7.5	9.0	9.0	9.0	9.0
1505	PI 368502	Yugoslavia	9.0	9.0	7.5	9.0	9.0	9.0	9.0
1506	PI 357710	Yugoslavia	9.0	9.0	7.5	9.0	9.0	9.0	9.0
1507	PI 277987	Turkey	9.0	9.0	7.6	9.0	9.0	9.0	9.0
1508	PI 357735	Yugoslavia	9.0	9.0	7.6	9.0	9.0	9.0	9.0
1509	PI 379226	Yugoslavia	9.0	9.0	7.6	9.0	9.0	9.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1510	PI 381707	India	9.0	9.0	7.6	9.0	9.0	9.0	9.0
1511	PI 438677	Mexico	9.0	9.0	7.6	9.0	9.0	9.0	9.0
1512	PI 482255	Zimbabwe	9.0	9.0	7.6	9.0	9.0	9.0	9.0
1513	PI 593370	China	9.0	9.0	7.6	9.0	9.0	9.0	9.0
1514	PI 357750	Yugoslavia	9.0	9.0	7.6	9.0	9.0	9.0	9.0
1515	PI 500316	Zambia	9.0	9.0	7.6	9.0	9.0	9.0	9.0
1516	PI 518610	Russi	9.0	9.0	7.6	9.0	9.0	9.0	9.0
1517	PI 612461	Korea	9.0	9.0	7.6	9.0	9.0	9.0	9.0
1518	PI 271774	S. Africa	9.0	9.0	7.6	9.0	9.0	9.0	9.0
1519	PI 277999	Turkey	9.0	9.0	7.6	9.0	9.0	9.0	9.0
1520	PI 345545	Ukraine	9.0	9.0	7.6	9.0	9.0	9.0	9.0
1521	PI 165002	Turkey	9.0	9.0	7.6	9.0	9.0	9.0	9.0
1522	PI 357707	Yugoslavia	9.0	9.0	7.6	9.0	9.0	9.0	9.0
1523	Quetzali	USA	9.0	9.0	7.6	9.0	9.0	9.0	9.0
1524	PI 275628	Pakistan	9.0	9.0	7.7	9.0	9.0	9.0	9.0
1525	PI 271988	Somalia	9.0	9.0	7.7	-	9.0	9.0	9.0
1526	PI 169292	Turkey	9.0	9.0	7.7	9.0	9.0	9.0	9.0
1527	PI 357719	Yugoslavia	9.0	9.0	7.7	9.0	9.0	9.0	9.0
1528	PI 378616	Zaire	9.0	9.0	7.7	9.0	9.0	9.0	9.0
1529	PI 167126	Turkey	9.0	9.0	7.7	9.0	9.0	9.0	9.0
1530	PI 269466	Pakistan	9.0	9.0	7.7	9.0	9.0	9.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1531	PI 344300	Turkey	9.0	9.0	7.7	-	.	9.0	-
1532	PI 357752	Yugoslavia	9.0	9.0	7.7	9.0	9.0	9.0	9.0
1533	PI 368499	Yugoslavia	9.0	9.0	7.7	9.0	9.0	9.0	9.0
1534	PI 512364	Spain	9.0	9.0	7.7	-	.	9.0	-
1535	PI 549160	Chad	9.0	9.0	7.7	-	9.0	9.0	9.0
1536	PI 357668	Yugoslavia	9.0	9.0	7.7	9.0	9.0	9.0	9.0
1537	Grif 12335	China	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1538	PI 167219	Turkey	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1539	PI 632753	USA	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1540	PI 164998	Turkey	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1541	PI 169242	Turkey	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1542	PI 169277	Turkey	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1543	PI 278042	Turkey	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1544	PI 288522	India	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1545	PI 357692	Yugoslavia	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1546	PI 357724	Yugoslavia	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1547	PI 319235	Japan	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1548	PI 357685	Yugoslavia	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1549	PI 357716	Yugoslavia	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1550	PI 278057	Turkey	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1551	PI 295850	S. Africa	9.0	9.0	7.8	9.0	9.0	9.0	9.0

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Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Virus rating Rep1	Virus rating Rep2	Virus rating Rep3	Virus rating Rep4
1552	PI 345547	Ukraine	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1553	PI 357656	Yugoslavia	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1554	PI 357734	Yugoslavia	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1555	PI 368509	Yugoslavia	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1556	PI 379222	Yugoslavia	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1557	PI 482287	Zimbabwe	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1558	PI 275632	India	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1559	PI 357669	Yugoslavia	9.0	9.0	7.8	9.0	9.0	9.0	-
1560	PI 171579	Turkey	9.0	9.0	7.8	-	9.0	9.0	9.0
1561	PI 357696	Yugoslavia	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1562	PI 271749	Afghanistan	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1563	PI 438674	Mexico	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1564	PI 172799	Turkey	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1565	PI 368525	Yugoslavia	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1566	PI 167026	Turkey	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1567	PI 167222	Turkey	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1568	PI 226445	Israel	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1569	PI 278033	Turkey	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1570	PI 357658	Yugoslavia	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1571	PI 357712	Yugoslavia	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1572	PI 357722	Yugoslavia	9.0	9.0	7.8	9.0	9.0	9.0	9.0

(continued next page)

Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
1573	PI 381714	India	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1574	PI 381747	India	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1575	Rhode Island	USA	9.0	9.0	7.8	9.0	9.0	9.0	9.0
1576	Sugar loaf	USA	9.0	9.0	7.9	-	9.0	9.0	9.0
1577	PI 212208	Greece	9.0	9.0	7.9	9.0	-	9.0	9.0
1578	PI 169278	Turkey	9.0	9.0	7.9	9.0	-	9.0	9.0
1579	PI 271771	S. Africa	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1580	PI 368503	Yugoslavia	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1581	PI 381748	India	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1582	PI 357667	Yugoslavia	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1583	PI 277993	Turkey	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1584	PI 175650	Turkey	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1585	PI 176908	Turkey	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1586	PI 512331	China	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1587	PI 381754	India	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1588	PI 536464	Maldives	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1589	PI 368530	Yugoslavia	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1590	PI 169275	Turkey	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1591	PI 271467	India	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1592	PI 381755	India	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1593	PI 214044	India	9.0	9.0	7.9	9.0	9.0	9.0	9.0

(continued next page)

Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
1594	PI 277974	Turkey	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1595	PI 357702	Yugoslavia	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1596	PI 271748	Afghanistan	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1597	PI 357684	Yugoslavia	9.0	9.0	7.9	9.0	9.0	9.0	9.0
1598	Black Diamond YF	USA	9.0	9.0	8.0	-	9.0	-	-
1599	PI 197416	Ethiopia	9.0	9.0	8.0	9.0	9.0	9.0	9.0
1600	PI 532667	Zimbabwe	9.0	9.0	8.0	9.0	-	.	-
1601	PI 536544	India	9.0	9.0	8.0	9.0	9.0	9.0	9.0
1602	PI 596692	S. Africa	9.0	9.0	8.0	-	9.0	9.0	-
1603	PI 164634	India	9.0	9.0	8.0	9.0	9.0	9.0	9.0
1604	PI 169247	Turkey	9.0	9.0	8.0	9.0	9.0	9.0	9.0
1605	PI 179886	India	9.0	9.0	8.0	9.0	9.0	9.0	9.0
1606	PI 381746	India	9.0	9.0	8.0	9.0	9.0	9.0	9.0
1607	PI 314148	Soviet Union	9.0	9.0	8.0	9.0	9.0	9.0	9.0
1608	PI 542117	Botswana	9.0	9.0	8.0	-	-	-	9.0
1609	PI 596682	S. Africa	9.0	9.0	8.0	-	9.0	-	-
1610	Tender Sweet OF	USA	9.0	9.0	8.0	-	-	-	9.0
1611	PI 427298	India	9.0	9.0	8.1	9.0	9.0	9.0	9.0
1612	PI 250145	Pakistan	9.0	9.0	8.1	9.0	9.0	9.0	9.0
1613	PI 307750	Philippines	9.0	9.0	8.1	9.0	9.0	9.0	9.0
1614	Navajo Sweet	USA	9.0	9.0	8.1	9.0	9.0	9.0	9.0

(continued next page)

Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
1615	PI 379240	Yugoslavia	9.0	9.0	8.1	9.0	9.0	9.0	9.0
1616	PI 176917	Turkey	9.0	9.0	8.1	9.0	9.0	9.0	9.0
1617	PI 181935	Syria	9.0	9.0	8.1	9.0	9.0	9.0	9.0
1618	PI 357700	Yugoslavia	9.0	9.0	8.1	9.0	9.0	9.0	9.0
1619	PI 164639	India	9.0	9.0	8.1	9.0	9.0	9.0	9.0
1620	PI 167045	Turkey	9.0	9.0	8.1	9.0	9.0	9.0	9.0
1621	PI 172804	Turkey	9.0	9.0	8.1	9.0	9.0	9.0	9.0
1622	PI 172805	Turkey	9.0	9.0	8.1	9.0	9.0	-	9.0
1623	PI 278055	Turkey	9.0	9.0	8.2	9.0	9.0	9.0	9.0
1624	PI 169244	Turkey	9.0	9.0	8.2	9.0	9.0	9.0	9.0
1625	New Winter	Spain	9.0	9.0	8.2	9.0	9.0	9.0	9.0
1626	PI 172800	Turkey	9.0	9.0	8.2	9.0	9.0	9.0	9.0
1627	PI 512352	Spain	9.0	9.0	8.2	9.0	9.0	9.0	9.0
1628	PI 176907	Turkey	9.0	9.0	8.2	9.0	9.0	9.0	-
1629	PI 368523	Yugoslavia	9.0	9.0	8.2	9.0	9.0	9.0	-
1630	Desert King	USA	9.0	9.0	8.3	9.0	9.0	9.0	9.0
1631	PI 217522	Pakistan	9.0	9.0	8.3	9.0	9.0	9.0	9.0
1632	PI 536457	Maldives	9.0	9.0	8.3	9.0	9.0	9.0	9.0
1633	PI 169241	Turkey	9.0	9.0	8.3	9.0	9.0	9.0	9.0
1634	PI 182935	India	9.0	9.0	8.3	9.0	9.0	9.0	9.0
1635	PI 251244	India	9.0	9.0	8.4	9.0	9.0	9.0	9.0

(continued next page)

Appendix table 4. (continued).

Rank	Accession or cultivar	Country of origin	Virus rating Best	Virus rating Average	Virus rating Max.	Rep1	Rep2	Rep3	Rep4
1636	PI 381752	India	9.0	9.0	8.4	9.0	9.0	9.0	9.0
1637	PI 278058	Turkey	9.0	9.0	8.4	9.0	9.0	9.0	9.0
1638	PI 271987	Somalia	9.0	9.0	8.4	9.0	9.0	-	9.0
1639	PI 271750	Ghana	9.0	9.0	8.6	9.0	-	9.0	9.0
1640	PI 270143	India	9.0	9.0	8.8	-	9.0	-	9.0
1641	PI 269679	Belize	9.0	9.0	9.0	9.0	9.0	9.0	9.0
1642	PI 273480	Ethiopia	9.0	9.0	9.0	-	9.0	-	-
1643	Grif 14201	India	-	-	-	-	-	-	-
1644	Grif 14202	India	-	-	-	-	-	-	-
1645	PI 271468	India	-	-	-	-	-	-	-
1646	PI 271767	S. Africa	-	-	-	-	-	-	-
1647	PI 274034	S. Africa	-	-	-	-	-	-	-
1648	PI 381745	India	-	-	-	-	-	-	-
1649	PI 386014	Iran	-	-	-	-	-	-	-
1650	PI 532670	Zimbabwe	-	-	-	-	-	-	-
1651	PI 542113	Botswana	-	-	-	-	-	-	-
1652	PI 542118	Botswana	-	-	-	-	-	-	-
1653	PI 596679	S. Africa	-	-	-	-	-	-	-
1654	PI 596691	S. Africa	-	-	-	-	-	-	-
LSD (5%)			0.79	0.73	0.79				

[+] Plants were rated on a scale of 0-9 on the basis of severity of viral symptoms, where 0=none, 1-2=trace, 3-4=slight, 5-6=moderate, 7-8=severe, and 9=plant dead. Best is the average of rating 3 for the 4

replications. Maximum is the average of rating 3 for all of the replications. Average is the overall average of all the ratings for all the replications.