ABSTRACT

CALL, ADAM DEAN. Studies on Resistance to Downy Mildew in Cucumber (*Cucumis sativus* L.) Caused by *Pseudoperonospora cubensis.* (Under the direction of Todd C. Wehner, M.S.)

Downy mildew, caused by the oomycete pathogen *Pseudoperonospora cubensis* (Berk. And Curt) Rostov, is a major foliar disease of cucumber (*Cucumis sativus* L.) Currently, high yield and quality in the presence of downy mildew is achieved with multiple fungicide applications. Most of the currently grown cultivars have some resistance to downy mildew. Prior to a 2004 outbreak in the United States, host resistance was sufficient to control the disease, and downy mildew was only a minor problem on cucumber. There are currently no cultivars that show resistance at a level equal to that seen prior to 2004. However, differences in resistance among cultivars exist, ranging from moderately resistant to highly susceptible. Both host resistance and fungicides contribute to control of downy mildew for growers. Experiments were conducted to identify resistant and high yielding cultigens and and to determine the contribution of resistance and fungicides to overall control of downy mildew.

There were three major experiments. All experiments rated disease using a 0 to 9 scale (0=none, 1-2=trace, 3-4=slight, 5-6=moderate, 7-8=severe, 9=dead). The objective of experiment 1 was to identify new sources of resistance to downy mildew among plant introduction accessions from the U.S. National Plant Germplasm System, elite cultivars, and breeding lines of cucumber. The 1300 cultigens were tested at Clinton NC, USA, and

Skierniewice, Poland during 2005-2007 under natural field epidemics of the disease in unreplicated trials. Mean ratings for downy mildew leaf damage in the germplasm screening ranged from 1.0 to 7.3 in North Carolina and from 0.3 to 9.0 in Poland. The 40 most resistant and 10 most susceptible cultigens, along with 22 check cultivars were further evaluated in replicated field and greenhouse experiments in North Carolina and India in 2007 to 2009 for a total of eight environments (year by location). A fungicide component was added in 2008 and 2009 in that one environment each year was a field treated weekly with applications of Previcur Flex and Mancozeb alternating with Bravo and Tanos. Results from the retest study in NC confirmed the results of the initial screening study. The most resistant and most susceptible cultigens in the screening study were also the most resistant and most susceptible cultigens in the field retest. Cultigens were found that significantly outperform checks. High yielding and tolerant cultigens were also been identified, which could be used in developing improved cultivars.

The objective of experiment 2 was to identify cultivars having high yield and resistance to the new downy mildew. The experiment had 86 cultigens, three locations (Clinton and Castle Hayne, NC, and Bath, MI), three years (2007 to 2009) and 4 replications per location. None of the cultigens tested in this study showed a high level of resistance, although differences in resistance and yield among cultigens do exist.

The objective of experiment 3 was to evaluate different fungicide treatments, chosen to represent different levels of efficacy, combined with different levels of resistance (resistant - M 21, moderate - 'Sumter', susceptible - 'Wisconsin SMR-18') among cultigens for the effect on disease severity and yield. There were six and twelve replications in 2008 and 2009, respectively. Cultigen had a large effect in both years. As expected, using a resistant cultivar significantly improved resistance and most yield traits compared to a susceptible cultivar. Fungicide has a smaller effect on resistance traits and larger effect on total yield and percent marketable yield. To achieve maximum yield both a resistant cultivar and fungicide spray program should be used.

Studies on Resistance to Downy Mildew in Cucumber (*Cucumis sativus* L.) Caused by *Pseudoperonospora cubensis*

by
Adam Dean Call

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APPROVED BY:

J. Paul Murphy, Ph.D.	Peter S. Ojiambo, Ph.D.

Todd C. Wehner, Ph.D.
Chair of Advisory Committee

BIOGRAPHY

I was born in Kansas City, Kansas on the 25th of March, 1983. For as long as I can remember, science has been a primary focus in my education. I realized my interest in plant science while continuing my grandfather's tomato gardening tradition, following his death in 2001. From that time forward, I began taking classes in horticulture, further expanding my interest and knowledge. During my undergraduate studies at Kansas State University, I worked in a pathology lab which focuses on bacterial leaf blight in rice. My summers were spent managing markets for a vegetable farmer in the area. I also spent one summer as an intern on the Cucurbit Breeding Project at North Carolina State University. Following my undergraduate studies at KSU, the desire to continue my education led me back to NCSU. I am now looking forward to the completion of my master's degree and the continuation of my research and education as a PhD student.

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I would like to thank my major professor Dr. Todd Wehner for his guidance during my MS studies. His dedication and work ethic are an inspiration. I also want to thank Dr. Paul Murphy, Dr. Peter Ojiambo and Dr. Gerald Holmes for their support as my committee members. A special thanks for Ms. Tammy Ellington for her friendship and guidance. I would also like to thank Mr. Allan Gordon, Mrs. Laura Arrejano, Mr. Rakesh Kumar, Mrs. Antonia Teteh, Mrs. Jiyoung Oh, Mrs. Lingli Lou, Mr. Mahehdra Dia, and Ms. Marlene Taja for all the efforts that they put into my experiments. I would also like to thank the crews at the Horticultural Crops Research Stations in Clinton and Castle Hayne, NC for their hard work on my experiments. Finally, I would like to thank my parents for the support and guidance they have given me throughout my life.

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Adam D. Call, Adam D. Criswell, Todd C. Wehner, Urszula Klosinska and Elzbieta Kozik

Screening Cucumber (*Cucumis sativus* L.) for Resistance to Downy Mildew Caused by *Pseudoperonospora cubensis* (Berk. and Curt.) Rostow.

Adam D. Call, Adam D. Criswell and Todd C. Wehner[1]

Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Received for publication _______________. Accepted for publication _______________. The use of trade names in this publication does not imply endorsement by the North Carolina Agricultural Research Service of the products named, or criticism of similar ones not mentioned.. Direct correspondence to Todd Wehner (Todd_Wehner@NCSU.Edu).

[1] Graduate research assistant, former graduate research assistant (currently assistant breeder, Syngenta) and professor, respectively. The authors gratefully acknowledge the technical assistance of Tammy L. Ellington. The authors thank the USDA North Central Regional Plant Introduction Station at Ames, Iowa for kindly providing seeds for the study.

Abstract

Downy mildew, a foliar disease caused by the oomycete *Pseudoperonospora cubensis* (Berk. and Curt.) Rostow. is one of the most destructive pathogens of cucurbits. Moderately resistant cultivars are available but yield losses are high in North Carolina and Poland without the use of fungicides. Fungicide resistance has been observed in populations of downy mildew. Higher levels of resistance are needed to reduce the use of fungicides while maintaining adequate yields. The objective of this experiment was to identify new sources of resistance to downy mildew among plant introduction accessions from the U.S. National Plant Germplasm System, elite cultivars, and breeding lines of cucumber. A total of 1300 cultigens were tested at Clinton NC, USA, and Skierniewice, Poland during 2005-2007 under natural field epidemics of the disease in unreplicated trials. Mean ratings for downy mildew leaf damage in the germplasm screening ranged from 1.0 to 7.3 in North Carolina and from 0.3 to 9.0 in Poland, on a scale of 0 to 9, where 0 indicates no disease symptoms.

Eighty-one cultigens were classified as highly resistant (1.0 to 3.0), 130 as moderately resistant (3.1 to 4.0), 406 as intermediate (4.1 to 6.0), 408 as moderately susceptible (6.1 to 7.0), and 271 as highly susceptible (7.1 to 9.0). The 40 most resistant and 10 most susceptible cultigens, along with 22 check cultivars were further evaluated in replicated field and greenhouse experiments in North Carolina and India in 2007 to 2009 for a total of eight environments (year by location). A fungicide component was added in 2008 and 2009 where one environment each year was treated with weekly applications of Previcur Flex and Mancozeb alternating with Bravo and Tanos. Results from the retest study in NC confirmed the results of the initial screening study. The most resistant and most susceptible cultigens in the screening study were also the most resistant and most susceptible cultigens in the field retest. The most resistant 10 cultigens, averaged over all environments were PI 605996, PI 330628, PI 197088, PI 197086, PI 605924, PI 197085, PI 618893, PI 432886, PI 432875, and PI 618937. These cultigens originated from India (5), Pakistan (1), and P.R. China (4). The most susceptible cultigens were Ames 25699, PI 344350, Ames 19225, and PI 171601. Cultigens have been found that significantly outperform checks in all resistance traits. More studies need to be done to determine the inheritance of this resistance. High yielding and tolerant cultigens have also been identified, which should be used in developing improved cultivars. Future breeding efforts should concentrate on combining the resistance from these different sources into breeding lines and cultivars.

Introduction

Cucumber (*Cucumis sativus* L.) is the fourth most widely grown vegetable crop in the world after tomato (*Lycopersicon esculentum* Mill.), cabbage (*Brassica oleracea* var. *capitata* L.), and onion (*Allium cepa* L.) (Tatlioglu, 1993). The Peoples Republic of China is the world leader in cucumber production, accounting for approximately 62% of the total, followed by Turkey, Iran, the Russian Federation and the United States (USDA, 2007). Cucurbit downy mildew, caused by the oomycete pathogen *Pseudoperonospora cubensis* (Berk. And Curt) Rostov, is a major foliar disease of cucumber (Palti and Cohen, 1980). Most cultivars currently grown in the United States have some resistance. Before a new race of the pathogen appeared in 2004, these cultivars had high resistance. Since then, fungicide spray programs have been necessary to protect the crop, resulting in increased cost to growers. New sources of resistance could substantially reduce or eliminate fungicide requirements.

Studies on the host range of *P. cubensis* indicate approximately 20 genera, including 50 species in the Cucurbitaceae, are hosts. A total of 19 host species are in the genus *Cucumis* (Palti and Cohen, 1980; Lebeda, 1992a; Lebeda and Widrlechner, 2003). In addition to cucumber, other economically important hosts of *P. cubensis* are melon (*Cucumis melo* L.), watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai), and squash (*Cucurbita* spp.) (Whitaker and Davis, 1962). Epidemics of downy mildew on the genus *Cucumis* have been observed in over 70 countries worldwide (Palti, 1974; Cohen, 1981). Between 1982 and 1988 the estimated incidence of downy mildew on cucumbers in North Carolina was

30% (St. Amand and Wehner, 1991). The average dollar loss per year was 2.9% based on yield and quality reduction. Cucumber yield losses from downy mildew remained minimal compared to other diseases until 2004 when a more virulent form of *P. cubensis* caused a 40% loss for cucumber growers (Colucci et al., 2006). The new strains of *P. cubensis* continue to infect cucumber in most production areas in the United States. These losses 1make it a major threat to cucumber production in the United States.

The cucurbit downy mildew pathogen is an obligate parasite and, with the rare exception of oospore production, can only survive and reproduce on living host tissue. In production regions where conditions are too harsh for *P. cubensis* to survive year round, is the pathogen is introduced through the spread of sporangia in wind and storms from warmer regions where the pathogen can overwinter on wild and cultivated hosts. In the United States, *P. cubensis* overwinters in areas with mild winter temperatures, such as southern Florida and southern Texas (Bains and Jhooty, 1976a). In 2006 and 2007, *P. cubensis* was reported in greenhouse cucumber operations in Ontario, Canada and there is concern that this could be another source of inoculum, primarily when the disease is not well controlled (Hausbeck, 2007). Downy mildew has been a serious problem in Poland since 1985 and was considered to be a major limiting factor for cucumber production in that country (Rondomanski, 1988).

Symptoms of cucumber downy mildew generally occur only on the foliage. Infection first appears as small water soaked lesions on the underside of leaves. Lesions are often angular, being bound by leaf veins, and turning chlorotic to varying degrees. Sporulation occurs on the undersides of the leaves. Chlorotic lesions eventually turn necrotic. Eventually the entire leaf will become necrotic and die. Symptoms vary depending on relative susceptibility of the cultigens. The most resistant cultigens exhibit a hypersensitive response (HR) with small necrotic or chlorotic flecks and sparse sporulation, while the most susceptible cultigens are highly chlorotic and necrotic. The HR type resistance was first described by Barnes and Epps (1954) in cucumber PI 197087, from a single resistance gene *dm1*. Resistance from PI 197087 was used intensively in breeding new cultivars, and most current cultivars are thought to have some resistance derived from PI 197087. This resistance proved effective for many years, but has since been overcome. *P. cubensis* has high evolutionary potential, and qualitative resistance is generally easily defeated. Bains (1991) described four categories of lesion type: 1. Faded green to dull yellow lesions, size restricted, slow necrosis. 2. Yellow spots or flecks, non-angular, slow growing, slow necrosis. 3. Bright yellow, large, angular, fast growing, susceptible type, high sporulation. 4. Necrotic spots or flecks, non-angular, little chlorosis, HR type. Most cultivar's lesions are best described as category 3 (personal observation and unpublished data). The determinate pickle 'M 21' resembles category 1. 'Heidan#1' shows lesion type 2.

Environmental conditions play a fundamental role in disease intensity (Cohen, 1977). Leaf wetness is critical for infection to occur, with sporangia requiring free moisture to germinate, but temperature determines the rate of disease. Sufficient leaf moisture can be supplied by rainfall, dew formation or irrigation. The ideal temperature for sporulation and subsequent infection is 15° C, but a range between 5 and 30° C will suffice. The pathogen generally thrives in warm humid regions. Variability in the pathogen population may also play a role in cucumber response to downy mildew. Several races of *P. cubensis* have been reported in differential test studies (Palti, 1974; Bains and Jhooty, 1976b; Inaba et al., 1986; Angelov et al., 2000; Shetty et al. 2002). Six pathotypes of *P. cubensis* have been reported based on their compatibility with specific host genera (Thomas et al., 1987; Cohen et al., 2003). Horejsi et al. (2000) stated that no evidence for race differences in the United States and European populations of *P. cubensis* exist. Shetty et al. (2002) proposed that at least two races of downy mildew exist, the race in P.R. China and India being distinct from the race present in the United States and Poland. Shetty et al. (2002) also stated that there is no evidence for race differences between the United States and Poland. However, recent studies indicated that European populations of *P. cubensis* are highly variable and may have many pathotypes (Lebeda and Urban, 2004). In the United States, *P. cubensis* does not seem to be as variable. However, historical (Barnes and Epps, 1954) and recent (Holmes et al., 2006) epidemics suggest that the pathogen has the potential to evolve. In the United States, cultivars previously resistant to downy mildew are still resistant to the new strain, but at a lower level. Now, resistant cultivars must be used in combination with fungicides for effective control of the disease. Strains of *P. cubensis* resistant to fungicides have been reported (Reuveni et al., 1980), and new sources of genetic host resistance are in high demand.

Wehner and Shetty (1997) examined downy mildew resistance in the United States germplasm collection of cucumbers, including cultivars, breeding lines, land races and plant introduction accessions from around the world, hereafter referred to as cultigens. They reported that in North Carolina, the most resistant cultigens were of U.S. origin and were primarily elite cultivars and breeding lines. Resistance from those cultigens traced back to PI 197087, which was originally identified as resistant by Barnes and Epps (1954). Interestingly, PI 197087 was found to be only intermediate in resistance in their screening studies, indicating a possible change in the PI accession since its original use in breeding. Staub et al. (1989) screened the germplasm collection for reaction to *P. cubensis*. They found that 6.2% of the 753 accessions tested were resistant to downy mildew and 7.2% were susceptible. The remaining accessions were segregating for resistance. Plants were rated only as resistant or susceptible, with susceptible being defined as having strong chlorosis. Of the resistant accessions, 34% were from China, 28% from Japan and 3% from India. Dhillon et al. (1999) tested 217 cultigens for downy mildew resistance in northern India, using natural infestations in the field, for downy mildew resistance. They reported that five of the nine most resistant cultigens were of Japanese origin, two were Indian landraces and two were European. Neykov and Dobrev (1987) also reported that the most resistant cultivars were of Asian origin, mostly from Japan, followed by India and P.R. China. In 1992 (Lebeda, 1992b) and 1994 (Lebeda and Prasil, 1994), 303 and 155 cucumber cultigens, respectively, were tested under controlled conditions for downy mildew resistance. Little resistance was reported in these tests. However, they suggested that some cultivars despite doing poorly in the greenhouse tests, had a high degree of field resistance.

Cucumber cultivars resistant to downy mildew have been developed (Sitterly, 1973; Wehner and Shetty, 1997) over the past 50 years. However, cultivars in the U.S. have been less resistant since 2004. We were interested in identifying higher levels of resistance in the germplasm collection, perhaps from diverse geographic regions, that could be combined to develop cultivars having higher resistance to the new form of the disease. We were also interested in evaluating the 352 accessions added to the germplasm collection since the previous screening studies in 1989. Thus, the objective of this study was to evaluate the available United States Department of Agriculture, Agriculture Research Service (USDA-ARS) cucumber germplasm collection for field resistance to downy mildew in North Carolina and Poland using commercial cultivars and breeding lines as checks.

Materials and Methods

Location and Seed Sources

Germplasm screening

Field studies were conducted at the Horticultural Crops Research Station in Castle Hayne, North Carolina, and at the Research Institute of Vegetable Crops in Skierniewice, Poland. All cucumber PI accessions were obtained from the North Central Regional Plant Introduction Station in Ames, Iowa. Countries with the most accessions in the collection of 1,289 were P.R. China (213), India (201), Turkey (171), Spain (70), Yugoslavia (66), Japan (63), Iran (63) and the United States (61) (Table 1.1). 19 cucumber cultivars ranging from moderately resistant to highly susceptible were used as reference entries for downy mildew infection. Check cultivars were 'Calypso' (North Carolina State Univ.), 'Coolgreen' (Seminis), 'Dasher II' (Seminis), Gy 4 (North Carolina State Univ.), 'Homegreen #2' (USDA-Wisconsin), 'H-19' (Univ. Arkansas), LJ 90430 (USDA-La Jolla), M 21 (NC State Univ.), M 41 (North Carolina State Univ.), 'Marketmore 76' (Cornell Univ.), 'National Pickling' (National Seed Storage Laboratory), 'Poinsett 76' (Cornell Univ.), 'Slice' (Clemson Univ.), 'Straight 8' (National Seed Storage Laboratory), 'Sumter' (Clemson Univ.), 'Tablegreen 72' (Cornell Univ.) 'TMG-1' (P.R. China), WI 2757 (USDA-Wisconsin) and 'Wisconsin SMR 18' (Wisconsin AES).

Germplasm retest

The 40 most resistant and 10 most susceptible cultigens were tested under field and greenhouse (2007 only) conditions in North Carolina and field conditions in Bangalore India (2007 only). 20 additional cultigens of interest were added in 2008 and 2009. Controlled experiments were conducted in greenhouses at the Horticulture Field Laboratory (HFL) at North Carolina State University in Raleigh, North Carolina. Field experiments were conducted at the Horticultural Crops Research Stations in Clinton, and Castle Hayne, North Carolina, and at the Indian Institute of Horticultural Research (IIHR), in Bangalore, India. Countries with the most accessions in the retest were P.R. China (22), India (14), and United States (12) (Table 1.2). Plant introduction accessions of *Cucumis* were obtained from the North Central Regional Plant Introduction Station in Ames, Iowa. 22 cucumber cultivars ranging from moderately resistant to highly susceptible were used as checks. Check cultivars were ‘Ashley’ (Clemson Univ.) ‘Calypso’ (North Carolina State Univ.), ‘Coolgreen’

(Asgrow), ‘Dasher II’ (Seminis), Gy 4 (North Carolina State Univ.), Gy 57u (North Carolina State Univ.), 'Heidan #1' (PR China), ‘Homegreen #2’ (USDA-Wisconsin), H-19 (Univ. Arkansas), 'LJ 90430' (USDA), M 21 (North Carolina State Univ.), ‘Marketmore 76’ (Cornell Univ.), 'National Pickling' (NSSL), ‘NongChen #4’ (PR China), ‘Poinsett 76’ (Cornell Univ.), 'Polaris' (Clemson Univ.), ‘Slice’ (Clemson Univ.), ‘Straight 8’ (National Seed Storage Laboratory), ‘Sumter’ (Clemson Univ.), WI 2238 (USDA-Wisconsin), WI 2757 (USDA-Wisconsin) and ‘Wisconsin SMR 18’ (Wisconsin AES).

Inoculation Procedure

In the field, plots were exposed to natural epidemics in the course of the growing season. Susceptible cultivars 'Straight 8' (2008 only) and 'Coolgreen' were used in borders around the field and spreader rows spaced every ninth row to monitor and increase inoculum in the field. Epidemics were encouraged using overhead irrigation. Plots were planted when border rows displayed major symptoms of disease.

For the greenhouse retest, cucumber leaves infected with *P. cubensis* were collected from fields in Clinton, North Carolina that had not been sprayed with fungicides. Leaves were collected in the morning, placed in plastic bags (Ziploc brand) and stored in a cooler with ice and transported to the laboratory, where five heavily-infected leaves were soaked in distilled water and rubbed gently with a glass rod to dislodge sporangia. The spore suspension was filtered through four layers of cheesecloth to remove dirt and debris and the concentration was determined with the use of a hemacytometer (Reichert Scientific Instruments, Bright-Line model). The suspension was adjusted to a final concentration between 8-12000 sporangia/mL. Immediately prior to inoculation, Tween 20 (0.06 g/L) was added to the inoculum suspension to keep the spores well dispersed in the solution.

In the greenhouse, plants were inoculated at the one- to two-true leaf stage with a hand-pump spray bottle (1 L size, Delta Industries). Inoculum was applied to upper and lower leaf surfaces of cotyledons and true leaves until run-off. Flats were placed in a dark growth chamber with humidifiers (100% RH, 20 °C) for 48 hours to maximize sporulation. Flats were then moved to a greenhouse (25 to 45°C) and plants were evaluated for disease 8 to 10 days after inoculation.

Field Ratings

Disease was evaluated as chlorotic lesions, necrotic lesions, degree of stunting, lesion size (2008 and 2009 only), and sporulation. Some traits were not evaluated for all years, locations, or ratings. Chlorosis, necrosis, and sporulation were rated on a 0 to 9 scale based on percentage of symptomatic leaf area; as described by Jenkins and Wehner (1983) (Table 1.3). The lesion size rating was designed to identify accessions showing hypersensitive response. Lesion size was rated broadly into three categories: S = small necrotic flecks (possibly hypersensitive response), M = medium chlorotic and necrotic lesions, and L = large angular lesions which were mostly chlorotic. In the field, lesion size was rated numerically as 1, 5, and 9 for small, medium and large respectively. Therefore the means of lesion size data are not very useful, except in identifying cultigens with means at low and high extremes. In this case, non-parametric analysis should be used, because for means in the middle of the range it cannot be determined if they were a mix, or consistently rated in the middle, without looking at the data. We will likely incorporate this technique in the future, but for this study, our main focus was identifying cultigens that showed smallest lesion size, indicated by the smallest overall mean.

Disease ratings were started when most test plots showed disease. Chlorosis and necrosis were rated visually as the percentage of leaves displaying each symptom. Plots were rated using all diseased leaves on all plants. Stunting was rated as reduction in plant size relative to the larger cultivars used as checks. It is a rating indicating the ability to grow large and branched. Therefore, even without disease, different genotypes would have different stunting ratings. Nevertheless, it allows us to identify those cultigens which remain large and highly branched under a disease epidemic. Stunting was rated on the last three dates only in 2008, due to the difficulty of rating that trait when plants were small. Lesion size was added as a disease component in 2008, with data taken on the second and third ratings (out of 6 total) only.

It is difficult to separate cultigens into resistant and susceptible classes since there were no obvious gaps in their distribution over the 0 to 9 scale. However, plant breeders often use those terms for quantitative traits. In keeping with that practice, and to remain consistent with previous studies, cultigens having ratings less than 3.0 were classified highly resistant, from 3.1 to 4.0 moderately resistant, from 4.1 to 6.0 intermediate, from 6.1 to 7.0 moderately susceptible, and from 7.0 to 9.0 highly susceptible.

Experiment Design

Germplasm screening

The experiment was an augmented design with two locations (Poland and North Carolina) and three years (2005 to 2007). Year was treated as a random effect and location as fixed. Data were analyzed using the General Linear Model, Means and Correlation procedures of the Statistical Analysis System (SAS Institute, Inc., Cary, NC).

Field tests were performed in 2005, 2006 and 2007 in Poland and North Carolina. Fertilizer was incorporated before planting at a rate of 90-39-74 kg/ha (N-P-K) with an additional 34 kg N/ha applied at the vine-tip-over stage (four to six true leaves). Seeds were planted by hand on raised, shaped beds with centers 1.5 m apart and plots 1.5 m long. Plots were later thinned to six plants at the first true leaf stage. Irrigation was applied when needed to provide a total of 25 to 40 mm per week and a tank mix of Curbit (Ethalfluralin) and Command (Clomazone) was applied preplant for weed control using the manufacturer's specified rates. Plots were separated at each end by 1.5 m alleys. Field plots were evaluated three times (on a weekly basis) after symptoms of downy mildew developed.

Germplasm retest

Selections were based on mean data over locations from the germplasm screening in 2005 and 2006. The 40 most resistant and 10 most susceptible cultigens were tested under field and greenhouse (2007 only) conditions in North Carolina and field conditions in Bangalore India (2007 only). 20 additional cultigens of interest were added in 2008 and 2009. Seeds for some cultigens were in limited supply and not grown in all years and cultigens were added as they became available in subsequent years. All cucumbers were grown using recommended horticultural practices as summarized by Schultheis (1990). Fertilizer was incorporated before planting at a rate of 90.6-90.6-90.6 kg/ha (N-P-K) with an additional 33.6 kg N/ha applied at the vine-tip-over stage (four to six true leaves).A tank mix of Curbit (Ethalfluralin) and Command (Clomazone) was applied preplant for weed control using the manufacturer's specified rates. Spreader rows planted with a 'Coolgreen', a highly susceptible check, were spaced every 9 rows in the field, with border rows on all sides. Ten seeds were hand planted in plots 1.5 m long on raised, shaped beds with centers 1.5 m apart, and 1.5 m alleys between plots in a row. Field plots were planted by hand on raised, shaped beds with centers 1.5 m apart and 1.5 m in length.

In greenhouse tests, seeds were pre-germinated for 36 to 48 hr to ensure maximum plant stand. Seeds were planted in 9x4 flats filled with a mix of peat, vermiculite and perlite (Sun Gro Horticulture, Metromix 200, Bellevue, WA). Greenhouse temperature was 45 / 25°C day / night. Greenhouse ratings were taken once, 8 to 10 days after inoculation, on 4 plants per cultigen.

In 2008, the retest experiment at Clinton was modified to a split block with the addition of a fungicide treatment for control of downy mildew to allow the measurement of tolerance (the ability to produce yield under a epidemic disease). Fungicides were whole plot with replications within fungicides. Two fields at the Horticultural Crops Research Station in Clinton, North Carolina were used. A fungicide treatment was applied weekly to one field as a mixture of Bravo and Previcure Flex alternating with Mancozeb and Tanos, beginning at true leaf stage. In 2009, two fields were at the Horticultural Crops Research Station in

Clinton, North Carolina and one field at the Horticultural Crops Research Stations in Castle Hayne, North Carolina. The fungicide treatment was applied to one field at the Clinton research station. No fungicide was used at Castle Hayne.

The 92 cultigens that were the most resistant or most susceptible for downy mildew resistance, were grown under heavy downy mildew incidence in the field. Some cultigens were not planted in all years because of seed limitations, and some cultigens were added to fill missing spots. Cultigens not grown in all environments, years, or locations, were not included in the analysis over environment, years, or locations. They were only included only if represented fully. Plots were rated weekly for disease (4, 5, and 6 ratings in 2007, 2008, and 2009, respectively), with yield data (two harvests) taken in 2008 and 2009 only. The experiment was a randomized complete block design with four replications in each environment. Data were analyzed using the General Linear Model, Means and Correlation procedures of SAS (SAS Institute, Inc., Cary, NC). Data were analyzed over eight environments from 2007 to 2009 (Table 1.4).

Results and Discussion

Germplasm screening

A significant cultigen effect for North Carolina, Poland and the two locations combined was found by analysis of variance (Table 1.5). There was also a significant cultigen by location interaction.

The use of multiple years and locations is important for identification of a high level of resistance, due to environmental influence of overall disease and disease progesss. The downy mildew rating at five weeks after planting in North Carolina was 4.8, 5.2, and 5.4, for each test in 2005, 2006 and 2007, respectively. The downy mildew rating at five weeks after planting in Poland was 6.2, 7.7, and 5.3 for each test in 2005, 2006 and 2007, respectively.

The F ratio for cultigen at each location over all years was highest for the rating taken five weeks after planting, so we considered that the most useful for distinguishing among cultigens. That rating had a higher F ratio and a lower coefficient of variation than the ratings at three or four weeks after planting.

Ratings taken at five weeks after planting were the last ratings of the season. This rating was used to rank the cultigens from most resistant to most susceptible because it gave the best indication of resistance or susceptibility (Table 1.6). Ratings taken at five weeks after planting are also useful indicators of how well cucumber plants are responding to downy mildew prior to fruit set. Cucumber cultigens, including resistant ones, appear to become more susceptible after fruit set (Barnes and Epps, 1950).

Data were summarized as the mean of all ratings taken at five weeks after planting for each location and combined over locations as well as standard deviations and number of missing observations (Appendix Table 1). Cultigens were ranked from most to least resistant based on ratings taken five weeks after planting.

The LSD (5%) for downy mildew resistance rating was 1.79 in North Carolina, 3.14 in Poland and 1.60 for locations combined. The LSD was higher in Poland than in North

Carolina. The extra variation may have been due to *Fusarium* wilt (caused by *Fusarium oxysporum* f. sp. *cucumerinum*) and angular leafspot (caused by *Pseudomonas syringae* pv. *lachrymans*) present in addition to downy mildew. Differences in disease severity between locations and among replications may have resulted in higher variability.

Cultigens resistant over multiple environments are preferred over those that are resistant in only one environment, so all cultigens were ranked using the combined results from Poland and North Carolina (Appendix Table 1). There were 81 highly resistant, 130 moderately resistant, 406 intermediate, 408 moderately susceptible and 271 highly susceptible cultigens. Data from Poland showed a greater range of mean downy mildew ratings compared with data from North Carolina (0.3 to 9.0 compared with 1.0 to 7.3, respectively). The most resistant PI accessions were not significantly more resistant than the most resistant commercial cultivars used in Poland or North Carolina.

Germplasm retest

Over the six environments not receiving a fungicide treatment, a significant cultigen and location effect was found for chlorosis, necrosis, and stunting (Table 1.7). Significance was also found in chlorosis for year, cultigen by year, cultigen by location, and cultigen by year by location. For necrosis and stunting, significance was found for cultigen by year, year by location, and cultigen by location. The mean squares for these effects, although significant, were generally far less than the significant cultigen, location and year mean squares.

A subset of the data having four environments (Clinton, NC with and without fungicides, 2008 and 2009) was analyzed to determine the effect of fungicide on disease and yield traits, and to identify tolerance (the ability to produce yield under a disease epidemic),. A significant cultigen and fungicide effect was found for chlorosis, necrosis, and stunting (Table 1.8). Significance was also found for all traits for cultigen by year, cultigen by fungicide, and cultigen by year by fungicide.

In this subset of the data, all effects for total yield (year, fungicide, fungicide by year, replication within fungicide by year, cultigen, cultigen by year, cultigen by fungicide, and cultigen by fungicide by year) were significant at $p<0.001$. Significance for percent marketable fruit was found for all sources of variation except fungicide and replication within fungicide by year. For percent early fruit, all effects except fungicide were significant at $p<0.05$. Effect on mean fruit weight was significant for all sources of variation except replication within fungicide by year, and cultigen by fungicide by year. Significance in higher order interactions may have been due to the large number of degrees of freedom available for testing the effects (Table 1.9). The largest effects on yield traits were year, fungicide and fungicide by year. Because this was a disease study, it was designed to encourage disease, so yield from the checks was generally low and variable compared to a grower field where the system is optimized for high yield. A significant fungicide effect was found for total and marketable yield, and fruit size, but not for percentage early fruit. The cultigen effect on yield was significant for all yield traits, but the mean squares were far less than the year and fungicide effects. This is also likely due to the encouragement of disease versus optimizing for yield.

F ratio and coefficient of variation were examined for the means of all component ratings and the means of each weekly rating taken for each environment (Table 1.10). For chlorosis and necrosis, results indicated that the means of all ratings for each trait in each environment were most useful for determining differences among cultigens. These ratings had a higher F ratio and lower coefficient of variation than the means of any of the weekly ratings. The F ratio and coefficient of variation for stunting means over all ratings were not as consistent. For Bangalore, India in 2007, and all environments in 2008 and 2009, stunting ratings taken on the final date had the highest F ratio and lowest coefficient of variation. This is likely because differences among plots become progressively more apparent as the plants grew larger. Stunting data were taken on only two early ratings in Castle Hayne, NC in 2007, and not at all in the greenhouse tests. These results are important for future studies, as they indicate that stunting ratings need only be taken on the final one or two rating dates, saving time and labor.

To compare environments, data was standardized to a mean of 4.5 and standard deviation of 1.5. A combined best rating was devised that consisted of the means of the best weekly ratings for chlorosis, necrosis, and stunting in each environment. No stunting data were taken in greenhouse tests. Greenhouse data are presented separately. F ratio and coefficient of variation were examined for the means of each weekly rating taken for each environment do determine the combined best rating. For example, in 2008, for both environments, the combined best rating was the mean of the chlorosis, necrosis, and stunting data taken on the fifth weekly rating. In 2009, for all environments, the combined best rating was the mean of the fourth weekly rating for chlorosis and necrosis, and the fifth weekly rating for stunting. The combined best rating was kept consistent for all North Carolina locations within each year.

Cultigens showing high resistance for all traits in all environments would be most useful, so the combined best standardized ratings for chlorosis, necrosis, and stunting were used to compare performance in the seven field environments (Table 1.11). Among the accessions that were tested in every environment, the top ten performing cultigens were PI 605996, PI 330628, PI 197088, PI 197086, PI 605924, PI 197085, PI 618893, PI 432886, PI 432875, and PI 618937. The mean combined ratings for these cultigens range from 2.8 to 3.8. The mean combined ratings for these cultigens with non-standardized data ranged from 2.1 to 3.4 (data not shown). The highest performing checks were 'Slice' and M21, with standardized mean best combined ratings over all environments of 4.0 and 4.1, respectively. Some cultigens were not tested in all environments. Cultigens performing significantly better than 'Slice' but not tested in all environments include (LSD 5%=0.5) PI 605928, Ames 20089, PI 618907, and PI 618861. Gy57u was top ranked, with a mean of 3.7, but was only tested in 2009.

The greenhouse results were variable and some cultigens did not exhibit typical responses (Table 1.12). For example, 'Straight 8', a susceptible check cultivar, was rated highly resistant. Some of the results may be explained by high greenhouse temperature

(45°C) during the test. The mean ratings for the greenhouse test ranged from 0.6 to 6.3 with an LSD (5%) of 1.70. Field ratings at Castle Hayne, NC in 2007 ranged from 0.5 to 7.2, with an LSD (5%) of 1.31.

Cultigens tested in Clinton, NC in 2008 and 2009 with and without fungicide were ranked by their combined best rating (see above) of chlorosis, necrosis, and stunting (Table 1.13). The most resistant ten accessions were PI 605996, PI 618893, PI 330628, PI 605924, PI 605928, PI 197086, PI 197088, PI 432875, PI 618861, and PI 618937. The ten also performed well in the screening and retest experiments run in other environments. Disease data from environments with weekly fungicide treatments of Tanos and Previcur Flex alternating with Bravo and Mancozeb, in Clinton, NC in 2008 and 2009 showed reduced means over all ratings for chlorosis (3.3 vs. 4.5), necrosis (4.3 vs. 5.5), and stunting (3.6 vs. 4.3) and combined best ratings (3.7 vs. 4.6) compared to the no-fungicide controls. Lesion size showed a slight increase in overall mean in the fungicide environment versus the no-fungicide environments (6.9 vs. 6.7). This difference is very small and likely due to sampling error. In the field, some plots showed different lesion sizes, making them difficult to rate. These differences were generally observed on different parts of the plant, not on the same leaf. In future studies, we would like to devise an improved method for rating lesion size.

The weekly application of fungicide lowered the mean disease rating in the field by approximately 1 point on the 0 to 9 rating scale for Clinton, NC in 2008 and 2009. The effect on yield was larger (Table 1.14) with mean total yield increasing from 7.2 to 15.9

Mg/ha, a 121% increase. Marketable yield increased from 5.1 to 13.4 Mg/ha, a 163% increase. Fungicide also had a significant effect (p=0.001) on percentage marketable yield, or total yield minus culls (Table 1.9). We used the original definition of tolerance, the ability to produce yield under a disease epidemic. Mean total marketable yield ranged from 0.0 to 25.8 Mg/ha in no-fungicide environments (Table 1.14). High yielding cultigens in no-fungicide fields over both years (2008 and 2009) include PI 618907, PI 432885, PI 197086, Ames 20089 and PI 330628. Some high yielding cultigens yielded similarly in both fungicide and no-fungicide treated locations (PI 618907 and PI 197086). PI 432885 had a mean yield of 36.3 Mg/ha in the fungicide environments compared to 25.8 Mg/ha in no-fungicide treated environments. Mean total marketable yield ranged from 0.9 to 43.6 Mg/ha in no-fungicide environments. The mean percentage early yield (harvest 1 of 2) decreased slightly from 27.8 to 23.8 in untreated and fungicide-treated environments, respectively. This was likely due to a drop in yield for the second harvest of no-fungicide treated environments. Increased disease between harvests causes reduction in photosynthesis and therefore yield was reduced as well.

Some cultigens were tested in 2009 only, so yield data for Clinton, NC with and without fungicide environments is presented in Table 1.15. The highest yielding cultigens without fungicide were PI 618907, PI 197086, and PI 330628 with 47.0, 36.7, and 35.4 Mg/ha, respectively. The highest yielding cultigens with fungicide were PI 618937, PI 330628, and PI 532523 with 64.6, 62.7, and 62.5 Mg/ha, respectively. Interestingly, the top cultigen for total yield, PI 618907, yielded similarly in both the fungicide and no-fungicide environments (49.0 and 47.0 Mg/ha, respectively). This cultigen stands out as tolerant, since it did not have a reduction in yield in non-fungicide environments, i.e. under heavy disease pressure. Other cultigens showing tolerance were PI 197086 and PI 432878 (Table 1.19). The top performing check in 2009 was Gy57u with 24.8 and 43.3 Mg/ha in no-fungicide and fungicide environment, respectively. Fungicide response for yield tended to be greater in susceptible cultivars. This result was also seen in a separate study on fungicide efficacy levels and levels of host plant resistance (unpublished data).

Cultigens that were resistant in the retest were also resistant in the germplasm screening experiment. Cultigens with the lowest ratings in the retest also had the lowest ratings in the germplasm screening. Cultigens showed reduced disease means in environments with fungicide compared to no-fungicide environments. Mean total and marketable yield was also much higher in fungicide treated fields. Cultigens were identified that are both resistant and high yielding. Tolerance has also been found in some high yielding cultigens.

All correlations were calculated using the Pearson product-moment correlation and Spearman rank correlation. Correlations of environments for disease were calculated using the mean chlorosis rating for each environment (Table 1.16). All combinations were significant at p=0.001 with the exception of the Spearman correlation of Bangalore, India in 2007 with the greenhouse tests at the Horticulture Field Laboratory in 2007. This combination had a correlation of 0.44 which was significant at p=0.01. Despite some unusual results in the greenhouse, correlation between the field and greenhouse germplasm retests was moderate.

Correlation of environments for yield was analyzed using the total yield (Mg/ha), marketable yield (Mg/ha) and percentage early fruit for fungicide and no-fungicide environments in Clinton, NC in 2008 and 2009 (Table 1.17). Total yield at Clinton, NC with fungicide in 2008 was not correlated with either environment in 2009. For marketable yield, the Spearman rank correlation was significant (p=0.001) between Clinton, NC with fungicide in 2008 and both fungicide and no-fungicide 2009 environments. The Pearson correlation was not significant. All environments were significantly correlated (at least p=.05) for percent early fruit using the Pearson correlation. The Spearman correlation did not find significant correlation between data from Clinton, NC with fungicide in 2008 and both environments in 2009.

Correlation of disease traits was measured using the mean of all ratings over environments (Table 1.18) for chlorosis, necrosis and stunting. Chlorosis and necrosis were highly correlated for the Pearson and Spearman tests (0.87 and 0.81, respectively), indicating they are likely the same trait. Both were also significantly correlated with stunting, but to a lesser extent at 0.35 and 0.34 for chlorosis and 0.42 and 0.36 for necrosis, respectively. Correlation of disease traits was also measured using the mean of all ratings over the subset of environments containing fungicide and no-fungicide treated Clinton, NC data from 2008 and 2009 (Table 1.19.). Chlorosis and necrosis were highly correlated for the Pearson and Spearman tests (0.90 and 0.83, respectively). Again, we believe these are likely the same trait. Stunting was significantly correlated with chlorosis (0.37 and 0.34), necrosis (0.34 and 0.30), and lesion size (0.53 and 0.56). This indicates stunting ratings are related to tissue lesions, but other factors influence stunting as well, namely differences in genotypes. Lesion size was significantly correlated with chlorosis (0.65 and 0.69), necrosis (0.61 and 0.62), and stunting (0.53 and 0.56). In the field it was observed that most susceptible cultigens, those showing high chlorosis and necrosis, also generally had large lesions. Most cultigens with small lesions were moderately to highly resistant.

Data from all environments in the retest were examined for cultigen variability over replications within tests. The inbred cultivars and plant introduction accessions varied similarly over replications and environments (Table 1.20). This suggests that the variability within the tests was not due to heterogeneity in an accession, but probably results from other effects, such as pathogen and environment. Although PI accessions are thought to be variable, it is likely that any genes for resistance were fixed upon being received to the collection, or became fixed during seed increases. During field ratings, plots with obvious variability in disease for plants within the plot were also not observed.

Conclusions

Cultigens have been found that significantly outperform checks in all resistance traits. More studies need to be done to determine the inheritance of this resistance. Resistant cultigens were resistant in all environments. High yielding and tolerant cultigens have also been identified, which could be used in developing improved cultivars. Environments with weekly fungicide applications outperformed no-fungicide environments in mean disease and yield ratings, with the greatest affect seen on total yield. Similar results were found in another study on resistance and fungicide levels (unpublished data).

Some cultigens that were resistant in other studies were also resistant in this study. Wehner and Shetty (1997) reported that Gy 4, 'Poinsett 76', M 21 and PI 234517 (SC50) were the most resistant. We found those cultigens to be moderately resistant. All of these sources have PI 197087 in their pedigree as the source of downy mildew resistance. PI 234517 (SC50) also has 'Ashley' as a source of resistance. The resistance from 'Ashley' is from 'P.R. 40' (Puerto Rico 40) and was reported by Barnes (1955). The combination of two resistance sources in PI 234517 did not give a significant increase in resistance compared with the resistance from PI 197087 alone. This suggests that the resistance from 'P.R. 40' is no longer useful. PI 197087 showed intermediate resistance in our germplasm screening study. This result was also reported by Wehner and Shetty (1997). They suggested that the accession may have lost resistance as it went through seed increase and maintenance. It now seems more likely that this resistance has been overcome, since cultivars that owe their resistance to PI 197087 (Gy 4, M 21, 'Poinsett 76') now also show only a moderate level of resistance.

There are at least two resistance genes to downy mildew in cucumber, one from PI 197087 and the other from 'P.R. 40'. If both of these genes have been overcome, which is suspected, the highly resistant cultigens in these studies likely have one or more resistance genes that have not been overcome. Further studies need to be run to determine if they two genes are allelic. Angelov (1994) reported that resistance in PI 197088 was due to two recessive genes and that ‘Poinsett’ resistance was due to one recessive gene. It is likely that the resistance gene in 'Poinsett' is from PI 197087 and possibly shared as one of the two resistance genes in PI 197088. PI 197088 is currently highly resistant, while cultigens tracing resistance back to PI 197087 are no longer highly resistant.

Staub et al. (1989) reported 22 PI accessions as having high resistance. Wehner and Shetty (1997) reported that 19 of those were highly resistant in their study. Interestingly, two of the most resistant cultigens from our study, PI 330628 and PI 197088, were only moderately resistant in the screening from 1997. The most resistant cultigens from their study, such as Gy 4 and 'Poinsett 76' were generally intermediate in our study. This may indicate allelism of the resistance gene in these cultigens. If PI 330628 and PI 197088 have a different allele of the same gene found in Gy 4 and 'Poinsett 76', it is possible that a single mutation could have caused the ability to overcome the more common allele (found in 'Poinsett 76' and tracing to PI 197087), and also the loss of the ability to overcome the allele in PI 197088 and PI 330628. This would explain the change in rank from before and after the outbreak in 2004.

Although they trace to the same source of resistance, some variability exists in the resistance of check cultivars. In the absence of a major resistance gene, resistance appears to be more quantitative. There may be minor genes that affect overall resistance when not masked by a major gene. Other factors such as overall vigor or plant architecture may play a role in resistance. In the field, highly vigorous plants did not appear to succumb to disease as quickly as less vigorous plants. Faster growth may allow the plant to outgrow the disease.

Cultigens with high resistance, high yield, and high tolerance have been identified. Breeders should utilize these cultigens in their programs in order to provide growers with cultigens that perform well in the face of the "new" downy mildew. Cultigens that were previously highly resistant no longer are, and should therefore only be used in breeding for improvement of traits separate from downy mildew resistance. Utilization of the top performing cultigens identified in this study should allow breeders to develop cultivars with high resistance, allowing growers to reduce or eliminate the need for fungicides. Although the fruit are not of marketable type, high yielding cultigens identified in the study may allow improvement of overall yield. The incorporation of cultigens showing tolerance to downy mildew for cultivar development may also have a major impact for growers, allowing the grower to achieve better yields even when disease pressure is high. Combining high resistance, high yield, and high tolerance with desired agronomic traits already available should lead to cultivars that are much improved over those available today.

Growers should continue to monitor downy mildew and use fungicides as necessary, following guidelines set out by their local extension agents. Growers should not just continue the use of cultivars that performed well in the past. They should be aware of new cultivars available each season, using all the information they can to choose the best cultivars for their situation. New cultivars with improved traits are always in the pipeline.

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Table 1.1. Countries of origin and number of PI accessions from the USDA-ARS. cucumber germplasm collection evaluated for resistance to downy mildew during the 2005 to 2007 seasons in Skierniewice, Poland and Clinton, NC, USA[z].

Seed source	No. of PI accessions
Afghanistan	16
Albania	1
Australia	3
Belgium	1
Bhutan	4
Brazil	2
Bulgaria	1
Canada	7
P.R. China	213
Czech Republic	14
Denmark	3
Egypt	22
Ethiopia	2
France	7
Georgia	3
Germany	5
Greece	1
Hong Kong	4
Hungary	21
India	201
Indonesia	1
Iran	63
Iraq	1
Israel	9
Japan	63
Kazakhstan	2
Kenya	1
Korea, South	16
Lebanon	4
Macedonia	1
Malaysia	2
Mauritius	1
Moldova	2
Myanmar	2
Nepal	6
Netherlands	40
New Zealand	2
Oman	3
Pakistan	14
Philippines	4
Poland	24
Puerto Rico	5
Russian Federation	60
Spain	70
Sri Lanka	1

Table 1.1 Continued

Sweden	4
Syria	14
Taiwan	12
Tajikistan	1
Thailand	2
Turkey	171
Ukraine	7
United States	61
United Kingdom	3
Uzbekistan	6
Yugoslavia	66
Zambia	6
Zimbabwe	2
PI accessions (total)	1281
Check Cultivars	15
Breeding lines	4
Total cultigens tested	1300

z Some countries listed as the origin of some accessions now no longer exist as political units.

Table 1.2. Countries of origin and number of PI accessions from each, and number of cucumber cultivars (checks) that were reevaluated for resistance to downy mildew in Raleigh, Clinton and Castle Hayne, North Carolina^{z}.

Seed source	Number
Czech Repub	01
Egypt	02
India	14
Iran	01
Japan	03
Korea, South	01
Lebanon	01
Pakistan	01
Philippines	02
PR China	22
Puerto Rico	01
Soviet Union	02
Syria	01
Taiwan	03
Turkey	03
United States	12
PI accessions (total)	70
Checks/Cultivars	22
Total cultigens tested*	92

z Some cultigens were not tested in all years, locations

Table 1.3. Subjective rating scale for field assessment of foliar resistance to downy mildew in cucumber for chlorosis and necrosis.

Subjective Rating	Percent of leaf area affected by chlorosis or necrosis	Description of symptoms
0	0	No symptoms
1	1-3	Trace
2	3-6	Trace
3	6-12	Slight
4	12-25	Slight
5	25-50	Moderate
6	50-75	Moderate
7	75-87	Severe
8	87-99	Severe
9	100	Plant dead

Table 1.4. Eight environments (locations by year) used in evaluation of selected cultigens of C. sativus for resistance to downy mildew[z].

Location	Year
Castle Hayne, NC	2007
Horticulture Field Lab (HFL), NCSU	2007
Bangalore, India	2007
Clinton, NC	2008
Clinton, NC - with fungicide*	2008
Castle Hayne, NC	2009
Clinton, NC	2009
Clinton, NC - with fungicide*	2009

z Fungicide applied weekly as Previcure Flex and Mancozeb alternating with Tanos and Bravo.

Table 1.5. Analysis of variance for the foliar downy mildew ratings of the evaluated U.S.D.A.-A.R.S. cucumber germplasm screening.

Source of variation	df	Mean Square	F Value	Pr>F
Dependent Variable: Ratings taken at week five for North Carolina and Poland				
Location	1	4980.85	4.37	0.1047
Year (Location)	4	1138.75	452.38	<.0001
Cultigen	1298	12.62	5.01	<.0001
Cultigen*Location	1286	3.96	1.57	<.0001
Error	4865	2.52		
Dependent Variable: Mean of all ratings taken at week five for Poland				
Cultigen	1298	13.21	3.44	<.0001
Year	2	1836.26	478.12	<.0001
Error	2467	3.84		
Dependent Variable: Mean of all ratings taken at week five for North Carolina				
Cultigen	1286	3.89	3.12	<.0001
Year	2	375.13	300.97	<.0001
Error	3332	1.25		

Table 1.6. F ratio and Coefficient of variation for mean of downy mildew ratings taken at 3, 4 and 5 weeks after planting for the germplasm screening in Poland and North Carolina.

Trait	Mean Square	F ratio	CV
Mean of all rating and all years for both locations	5.39	4.14	26.12
Mean of all ratings taken at 3 weeks after planting	7.41	5.14	42.05
Mean of all ratings taken at 4 weeks after planting	7.71	3.03	34.56
Mean of all ratings taken at 5 weeks after planting	11.78	4.77	27.69
Mean of all rating and all years for Poland	8.26	4.19	32.74
Mean of all ratings in Poland taken at 3 weeks after planting	4.52	2.60	73.46
Mean of all ratings in Poland taken at 4 weeks after planting	12.53	3.07	43.43
Mean of all ratings in Poland taken at 5 weeks after planting	16.01	4.17	30.52
Mean of all rating and all years for North Carolina	2.90	4.07	19.15
Mean of all ratings in NC taken at 3 weeks after planting	4.20	3.60	27.62
Mean of all ratings in NC taken at 4 weeks after planting	3.31	2.84	23.73
Mean of all ratings in NC taken at 5 weeks after planting	4.47	3.59	23.44

Table 1.7. Analysis of variance for downy mildew resistance trait means for data collected in six environments in North Carolina and India without fungicide treatment from 2007 to 2009[z].

Source of variation	df	Downy Mildew Resistance Components (mean squares) Chlorosis[y] rating	Necrosis[x] rating	Stunting[w] rating
Year	2	66.74 ***	3.07	
Location	4	196.71 ***	248.55 ***	
Year*Location	1	4.76	15.54 *	
Rep(Year*Location)	24	2.04 ***	2.20 ***	
Cultigen	91	42.83 ***	17.94 ***	
Cultigen*Year	131	1.68 ***	1.87 ***	
Cultigen*Location	279	3.26 **	1.70 ***	
Cultigen*Year*Loc.	70	0.74 **	0.63	
Error	1712	0.51 ***	0.51 ***	
Year	2			17.98
Location	3			93.88 ***
Year*Location	1			9.25
Rep(Year*Location)	21			6.52 ***
Cultigen	91			20.67 ***
Cultigen*Year	131			2.91 ***
Cultigen*Location	230			3.44 ***
Cultigen*Year*Loc.	70			1.16
Error	1566			0.98 ***
Year	1			
Location	2			
Year*Location	1			
Rep(Year*Location)	15			
Cultigen	89			
Cultigen*Year	70			
Cultigen*Location	173			
Cultigen*Year*Loc.	70			
Error	1627			

z Data are from 4 replications.
y Mean of all chlorosis ratings 2007-2009
x Mean of all necrosis ratings 2007-2009
w Mean of all stunting ratings 2007-2009.
*,**,*** Significant at 0.05, 0.01, and 0.001, respectively

Table 1.8. Analysis of variance for downy mildew resistance trait means for data collected in Clinton, North Carolina with and without fungicide treatment from 2008-2009[z].

Source of variation	df	Downy Mildew Resistance Components (mean squares) Chlorosis[y] rating	Necrosis[x] rating	Stunting[w] rating
Year	1	56.56 ***	2.98	0.00
Fungicide[u]	1	410.74 ***	458.19 ***	61.24 ***
Fungicide*Year	1	4.76 *	15.54 *	9.25 ***
Rep(Fung.*Year)	12	0.83 **	1.84 ***	5.00 ***
Cultigen	89	23.31 ***	12.62 ***	14.92 ***
Cultigen*Year	70	2.24 **	2.54 ***	3.03 ***
Cultigen*Fung.	89	0.96 ***	0.64 ***	1.73 ***
Cultigen*Fung*Year	70	0.74 ***	0.63 ***	1.16 *
Error	954	0.32	0.37 ***	0.83 ***

z Data are from four replications.
y Mean of all chlorosis ratings 2008-2009
x Mean of all necrosis ratings 2008-2009
w Mean of all stunting ratings 2008-2009
u Previcure Flex and Mancozeb alternating with Tanos and Bravo
*,**,*** Significant at 0.05, 0.01, and 0.001, respectively

Table 1.9. Analysis of variance for yield data collected in Clinton, North Carolina with and without fungicide treatment from 2008-2009[z].

Source of variation	df	Downy Mildew Yield (mean squares) Total (Mg/ha)	Marketable (%)	Early (%)	Fruit size (kg/fruit)
Year	1	92171 ***			
Fungicide[v]	1	20268 ***			
Fungicide*Year	1	18773 ***			
Rep(Fung.*Year)	12	480 ***			
Cultigen	89	812 ***			
Cultigen*Year	70	638 ***			
Cultigen*Fung.	89	151 ***			
Cultigen*Fung*Year	70	136 ***			
Error	954	62 ***			
Year	1		89520 ***	13820 *	
Fungicide[v]	1		100450 ***	7535	
Fungicide*Year	1		5	19606 **	
Rep(Fung.*Year)	12		683	2001 ***	
Cultigen	89		3062 ***	4489 ***	
Cultigen*Year	65		1344 ***	1123 ***	
Cultigen*Fung.	87		1485 ***	638 ***	
Cultigen*Fung*Year	51		923 ***	527 *	
Error	955		2455 ***	343 ***	
Year	1				3.833 ***
Fungicide[v]	1				0.245 ***
Fungicide*Year	1				0.126 **
Rep(Fung.*Year)	12				0.008
Cultigen	89				0.076 ***
Cultigen*Year	60				0.020 ***
Cultigen*Fung.	79				0.018 ***
Cultigen*Fung*Year	36				0.006
Error	824				0.010 ***

z Data are of 4 replications and 2 harvests for Clinton, NC in 2008-2009.
y Percent of total yield that is marketable in Mg/ha measured as total yield of non-culled fruit.
x Percent early fruit measured as yield from first harvest of two.
w Weight per fruit in kg measured on non-culled fruit.
v Previcure Flex and Mancozeb alternating with Tanos and Bravo
*,**,*** Significant at 0.05, 0.01, and 0.001, respectively

Table 1.10. F ratio and Coefficient of variation for downy mildew component ratings in environments (years x locations) tested in India and North Carolina 2007-2009[z].

			Chlorosis		Necrosis		Stunting	
Year	Location	Rating	F	CV	F	CV	F	CV
All	All	Avg	20.24	18.04	13.40	15.74	6.90	25.10
2007	Bangalore, India	1	15.82	38.42	4.38	45.84	-	-
		2	14.49	35.78	9.79	36.82	10.65	25.02
		3	12.08	36.52	2.19	14.36	12.15	23.58
		Avg	24.17	25.88	3.80	15.18	16.21	19.98
	Castle Hayne, NC	1	2.83	32.07	4.91	33.12	-	-
		2	3.55	27.55	2.75	21.54	3.77	28.29
		3	7.66	22.23	7.32	20.84	3.18	52.76
		4	5.44	29.34	4.47	27.40	-	-
		5	3.55	27.55	2.75	21.54	-	-
		Avg	10.29	16.01	9.67	14.64	3.67	35.55
	HFL	1	2.95	58.57	3.78	66.46	-	-
		2	3.54	57.83	2.79	71.24	-	-
		3	3.55	59.06	4.06	66.41	-	-
		4	2.08	62.81	2.75	64.85	-	-
		Avg	4.66	45.10	5.54	50.57	-	-
2008	Clinton, NC-Fung	1	5.41	34.96	2.01	33.36	-	-
		2	5.42	35.26	2.78	30.18	-	-
		3	7.21	26.25	4.13	19.31	-	-
		4	4.31	24.87	5.33	17.47	5.12	16.06
		5	9.94	25.61	7.65	25.25	7.51	31.85
		6	12.83	32.22	4.82	26.87	5.55	35.47
		Avg	29.08	15.27	7.74	13.11	6.46	20.58
	Clinton, NC	1	4.75	29.67	2.85	34.12	-	-
		2	2.06	37.42	1.91	34.28	-	-
		3	6.97	31.02	3.72	25.13	-	-
		4	7.98	28.87	4.64	22.33	3.89	16.36
		5	23.75	28.84	6.95	25.89	5.39	46.17
		6	6.69	25.63	6.40	18.57	12.40	24.62
		Avg	15.74	14.34	9.75	10.56	11.13	18.74
2009	Castle Hayne, NC	1	3.02	50.68	2.01	49.04	2.80	42.07
		2	7.31	16.45	3.01	24.39	2.89	38.67
		3	5.88	17.14	3.19	29.75	2.92	39.42
		4	14.56	21.98	7.35	30.99	5.16	33.32
		5	10.31	19.44	5.86	22.26	5.83	26.16
		Avg	17.95	11.13	9.35	15.78	4.22	28.36
	Clinton, NC-Fung	1	5.53	38.05	5.54	33.32	2.75	41.20
		2	5.25	41.54	5.03	34.28	4.30	36.61
		3	9.57	23.16	10.69	21.44	4.22	41.46
		4	16.96	22.91	15.41	20.04	5.57	36.08
		5	8.53	23.89	3.95	14.52	8.73	28.14
		Avg	22.53	15.65	18.02	12.80	5.67	28.05
	Clinton, NC	1	7.12	32.08	5.98	28.88	3.19	37.92
		2	11.43	21.92	6.15	19.67	3.65	35.51

Table 1.10 Continued

3	12.60	20.15	5.55	21.86	3.72	36.90
4	15.48	20.35	7.22	24.97	4.28	29.19
5	9.70	21.31	2.87	17.79	9.28	23.63
Avg	25.16	12.87	11.66	12.94	5.36	24.03

z Data are from four replications.
y Data are from Bangalore, India, in 2007.
x Data are from Castle Hayne, NC, in 2007.
wData are from Horticulture Field Laboratory, NCSU, Raleigh, NC, in 2007.
v Data are from Clinton, NC, in 2008 with fungicide.
u Data are from Clinton, NC, in 2008.
t Data are from Castle Hayne, NC, in 2009.
s Data are from Clinton, NC, in 2009 with fungicide.
r Data are from Clinton, NC, in 2009.

Table 1.11. Combined best downy mildew disease ratings in environments[z].

Year:		2007		2008		2009		
Location:	All	C.Hayne[y]	Bang.[x]	Clint.[w]	Clint.[v]	C.Hayne[u]	Clint.[t]	Clint.[s]
Fungicide[r]:	-	N	N	N	F	N	N	F
Cultivar								
PI 605996	2.8	3.1	2.9	3.2	3.4	3.6	2.4	2.7
PI 330628	2.9	2.1	3.6	2.9	3.4	2.4	1.7	2.2
PI 197088	2.9	2.5	3.5	3.2	3.3	1.9	1.6	2.3
PI 605928	3.0	.	.	3.3	3.7	4.0	3.6	4.0
PI 197086	3.0	2.3	3.4	3.4	3.8	2.5	1.9	3.3
PI 605924	3.0	3.4	3.3	3.9	4.0	3.7	3.5	3.5
PI 197085	3.1	2.1	3.2	3.3	4.0	3.2	2.6	2.7
Ames 20089	3.3	.	.	.	.	3.7	3.1	2.9
PI 618893	3.3	4.2	2.8	3.8	3.8	.	.	.
PI 618907	3.4	.	.	3.6	4.0	4.1	3.9	3.3
PI 618861	3.5	.	.	3.7	4.2	3.6	3.7	3.7
PI 432886	3.5	4.1	2.8	4.3	3.7	3.7	2.8	3.0
PI 432878	3.7	4.9	.	3.7	3.2	3.1	3.1	2.7
Gy57u	3.7	.	.	.	.	3.2	2.9	3.2
PI 390267	3.7	3.8	3.5	4.1	4.0	3.8	2.9	3.3
PI 432875	3.7	4.8	2.9	4.3	3.9	2.9	3.3	2.8
Ames 418962	3.7	.	.	.	.	3.7	3.7	3.8
PI 432885	3.7	.	.	.	.	3.6	3.2	2.8
PI 432874	3.8	.	3.0	3.8	3.5	3.4	3.0	2.7
PI 618937	3.8	4.4	3.2	4.7	3.7	4.5	4.5	3.7
PI 432876	3.8	.	.	.	.	3.8	2.8	3.3
PI 432884	3.8	4.2	2.8	4.2	3.8	3.5	3.3	3.4
PI 605995	3.8	4.8	5.1	5.1	4.2	3.9	4.4	4.4
PI 606051	3.8	4.9	5.8	4.0	4.2	5.4	4.8	4.4
PI 605932	3.9	3.1	3.7	3.0	3.3	2.9	3.2	3.7
PI 532523	3.9	.	.	6.5	5.0	4.6	5.1	4.4
PI 606017	3.9	4.9	5.0	4.3	4.3	4.7	4.6	4.9
TW-3	3.9	3.5	3.3	3.3	3.5	.	.	.
PI 606019	4.0	6.3	4.6	5.2	4.3	5.5	5.1	5.1
PI 432859	4.0	5.0	3.0	5.2	5.0	4.2	4.5	4.7
PI 606015	4.0	5.1	5.5	4.7	4.0	4.6	4.9	4.6
Ames 2353	4.0	2.2	2.8	3.4	2.9	3.3	3.7	3.6
PI 426170	4.0	3.9	4.4	3.2	3.0	3.8	4.0	3.5
TW-2	4.0	3.3	3.0	3.4	3.5	.	.	.
PI 518849	4.0	5.0	.	4.7	3.3	3.4	4.3	3.1
Slice	4.0	4.3	4.1	2.8	3.8	3.0	3.1	4.3
M 21	4.1	2.2	3.4	3.4	3.0	3.4	3.1	3.4
NongChen#4	4.1	4.3	3.0	5.2	4.8	5.3	4.9	4.4
Ames 2354	4.1	2.8	2.8	3.4	3.5	2.8	3.5	3.8
PI 321008	4.1	4.4	3.9	3.2	4.2	4.5	4.4	3.9
PI 618922	4.2	.	.	2.7	4.1	4.9	4.5	3.4
PI 432877	4.2	.	.	.	.	3.5	3.1	2.9

Table 1.11 Continued

PI 432882	4.2	.	.	.	.	3.0	3.6	3.5
SC 10	4.2	2.7	4.5	3.6	3.2	3.5	4.3	3.8
PI 605929	4.2	3.7	4.0	3.3	3.5	3.1	4.0	4.0
Model	4.2	.	.	3.3	3.1	4.1	4.0	4.4
Gy 4	4.3	3.4	4.4	3.3	3.2	3.6	4.3	4.8
PI 321009	4.3	4.1	4.0	2.9	4.0	4.1	4.1	4.3
Heidan#1	4.3	4.4	3.4	4.5	4.2	4.5	5.5	4.0
SC 50	4.3	3.6	3.5	3.2	3.2	2.7	3.7	3.8
PI 418963	4.4	4.8	3.4	4.6	3.7	4.9	4.2	5.4
Mariner H-423	4.4	4.3	4.0	5.0	3.5	4.2	4.7	4.1
Poinsett 76	4.5	3.5	3.7	3.6	3.1	3.2	3.6	4.1
PI 489753	4.5	.	.	3.8	5.2	5.4	4.5	4.4
Homegreen #2	4.5	4.8	5.5	3.4	3.7	3.8	4.0	4.0
PI 508455	4.5	5.2	3.5	4.8	4.2	5.1	5.7	4.6
TW-1	4.6	5.1	3.4	5.2	5.1	.	.	.
WI 2238	4.6	.	.	.	.	2.9	3.5	3.9
Polaris	4.7	.	.	2.5	3.3	3.5	3.3	3.7
Calypso	4.7	3.4	5.2	3.1	3.4	4.9	4.8	5.2
Marketmore 76	4.7	5.3	5.7	5.3	5.3	4.9	4.4	4.0
PI 618944	4.7	.	.	7.0	4.2	6.0	5.9	5.5
Sumter	4.8	4.4	.	4.3	3.9	4.1	4.8	5.2
TW-4	4.8	4.9	3.0	4.7	5.0	.	.	.
PI 618931	4.8	.	.	1.7	3.1	5.7	5.2	5.2
PI 618955	4.8	.	.	6.1	4.5	4.7	5.4	5.2
Dasher II	4.8	4.7	6.0	4.8	4.5	5.7	5.5	5.2
PI 511819	4.9	.	.	5.9	7.3	6.2	5.2	5.0
Ashley	4.9	5.6	5.3	4.7	4.6	4.6	5.6	4.6
Ames 426169	4.9	.	.	.	.	4.1	3.9	4.6
WI 2757	5.0	.	.	.	.	2.7	3.2	3.5
PI 179676	5.0	.	.	5.7	5.7	5.5	6.0	6.1
PI 267741	5.1	.	5.1	3.7	4.7	4.9	4.7	4.6
H-19	5.3	.	.	.	.	4.3	4.5	4.4
NationlPcklng	5.3	5.6	6.2	.	.	.	.	.
PR 39	5.4	.	.	.	.	5.6	5.8	5.1
LJ 90430	5.5	.	6.3	.	.	.	.	.
Ashe	5.9	.	.	.	.	5.7	5.9	5.3
Wis.SMR 18	6.0	6.6	6.7	7.0	6.9	6.5	6.9	8.2
PI 176523	6.1	5.9	6.5	6.9	7.4	7.0	6.9	7.1
PI 218199	6.2	6.7	6.4	6.1	7.1	6.1	7.1	7.8
PI 211983	6.2	5.4	6.7	6.8	7.6	6.7	7.0	7.0
Straight 8	6.3	5.4	6.5	6.2	7.1	7.0	6.7	6.5
PI 458851	6.3	6.2	7.0	6.7	6.9	6.2	7.1	7.2
PI 525151	6.4	6.4	6.6	6.6	7.4	7.2	6.8	7.0
Ames 23009	6.4	6.2	6.8	6.8	7.3	7.2	7.2	6.7
PI 171601	6.5	5.8	6.8	7.1	7.6	7.5	7.0	7.3
Poinsett	6.5	.	.	.	.	5.6	5.7	4.8
Ames 19225	6.5	6.5	6.0	6.1	4.5	6.4	6.8	6.9
PI 344350	6.7	6.9	6.8	7.4	6.8	7.2	6.9	7.6
Coolgreen	6.7	.	.	6.1	7.2	7.6	7.0	7.2

Table 1.11 Continued

Ames 25699	6.8	6.9	6.9	6.9	8.3	7.5	7.3	7.6
LSD (5%)	0.7	0.7	0.6	0.7	0.5	0.7	0.6	0.6

z Data are from four replications per location (HFL greenhouse not included) using combined best ratings (chlorosis, necrosis, stunting) based on F-value. Data are standardized to mean of 4.5 and standard deviation of 1.5.

y Data are from Castle Hayne, NC, in 2007.

x Data are from Bangalore, India, in 2007.

wData are from Clinton, NC, in 2008.

v Data are from Clinton, NC, in 2008 with fungicide.

u Data are from Castle Hayne, NC, in 2009.

t Data are from Clinton, NC, in 2009.

s Data are from Clinton, NC, in 2009 with fungicide.

r Weekly application of Previcure Flex and Mancozeb alternating with Tanos and Bravo.

Table 1.12. Mean greenhouse and field ratings for downy mildew foliar resistance of cucumber accessions in the germplasm retest studies in North Carolina, 2007.

Cultigen name	Seed source	Greenhouse rating[z]	SD	Missing Replications	Field rating[y]	SD	Missing Replications
PI 605929	India	0.6	0.6	0	4.6	1.4	0
PI 330628	Pakistan	0.7	0.5	0	2.3	0.6	0
PI 508455	South	0.7	0.6	0	5.9	1.2	0
PI 197085	India	0.8	0.3	0	1.9	0.9	0
PI 432886	P.R. China	1.0	0.7	0	4.3	1.4	0
PI 605924	India	1.0	1.2	0	3.8	1.2	0
Gy 4	NC State Univ.	1.1	1.7	0	3.6	0.8	0
PI 197088	India	1.1	0.6	0	3.1	1.4	0
Ames 7752	United States	1.2	0.8	0	3.0	1.1	0
Slice	Clemson Univ.	1.2	0.7	0	4.9	0.5	0
PI 605995	India	1.3	1.2	0	5.1	1.0	0
Ames 26084	United States	1.6	1.3	0	3.9	0.8	0
M 21	NC State Univ.	1.6	0.6	0	2.0	0.7	0
Homegreen #2	USDA-Wis.	1.7	0.7	0	5.2	1.0	1
PI 426170	Philippines	1.7	2.4	0	4.5	0.7	0
PI 432859	P.R. China	1.7	0.7	0	5.1	1.3	0
Calypso	NC State Univ.	1.8	1.1	0	4.3	0.5	0
PI 267741	Japan	1.9	0.3	1	7.2	1.6	1
PI 432875	P.R. China	1.9	1.1	0	4.9	1.5	0
Straight 8	United States	1.9	1.9	0	6.6	1.1	0
PI 605932	India	2.0	1.6	0	3.5	0.4	0
PI 321009	Taiwan	2.1	0.7	0	4.3	1.5	0
PI 432884	P.R. China	2.1	0.7	0	4.6	1.7	0
PI 618893	P.R. China	2.1	0.8	1	4.6	1.3	0
Sumter	Clemson Univ.	2.1	1.9	0	4.1	1.3	0
Nong Chen #4	P.R. China	2.3	0.7	0	3.9	0.6	0
Ames 2354	United States	2.4	1.3	0	3.4	1.4	0
PI 197086	India	2.5	0.4	0	1.9	0.5	0
Dasher II	Seminis	2.6	1.1	0	5.3	0.9	0
PI 321008	Taiwan	2.6	1.0	0	4.1	1.4	0
PI 605996	India	2.6	1.1	0	3.0	0.7	0
Ames 2353	United States	2.8	2.2	0	3.0	0.4	0
PI 606019	India	2.8	0.4	0	5.8	1.7	0
Ashley	Clemson Univ.	2.9	1.0	0	5.3	1.0	0
Marketmore 76	Cornell Univ.	3.0	2.1	0	5.6	1.0	0
PI 606015	India	3.0	0.5	0	5.0	0.7	0
PI 234517	United	3.1	1.1	0	4.3	2.2	0
PI 418963	P.R. China	3.1	0.5	0	4.6	0.6	0
PI 618937	P.R. China	3.1	0.6	0	4.8	1.0	0
WI 2757	USDA-Wis	3.1	1.9	0	-	-	4
PI 606017	India	3.2	0.8	0	4.9	1.3	0
Heidan #1	P.R. China	3.3	0.5	0	4.5	0.7	0
PI 606051	India	3.3	0.8	0	5.1	0.9	0
Poinsett 76	Cornell Univ.	3.3	1.7	0	3.8	1.0	0

Table 1.12 Continued

PI 390267	Japan	3.4	1.0	0	3.9	0.3	0
Ames 19225	Russian Federation	4.0	0.9	0	6.5	0.9	0
H-19	Univ. Arkansas	4.0	1.1	0	-	-	4
National Pickling	NSSL	4.0	1.3	0	6.2	1.3	1
Ames 23009	Czech Republic	4.2	0.8	0	6.8	0.3	0
PI 458851	USSR	4.2	1.5	0	6.6	0.9	0
Wis.SMR 18	Univ. Wisconsin	4.2	1.5	0	6.9	0.3	0
PI 344350	Turkey	4.4	1.3	0	6.9	0.9	0
PI 171601	Turkey	4.5	2.4	0	6.0	0.8	0
PI 176523	Turkey	4.7	0.9	0	6.0	0.7	0
PI 218199	Lebanon	5.0	2.6	0	6.4	0.5	0
PI 432874	PR Chi	5.0	1.1	1	7.0	3.5	1
PI 211983	Iran	5.2	1.1	0	6.1	0.5	0
Ames 25699	Syria	5.4	0.6	0	6.5	0.7	0
PI 525151	Egypt	6.3	0.3	0	6.4	0.8	0
LJ 90430	USDA, La Jolla	--	-	4	0.5	0.4	0
PI 432878	P.R. China	--	-	4	4.2	2.1	0
PI 518849	P.R. China	--	-	4	5.0	1.2	0
TMG-1	P.R. China	--	-	0	5.5	-	3
Chinese Long Green	Oris	-	-	4	--	-	4
PI 618931	P.R. China	-	-	4	--	-	4
LSD (5%)		1.31			1.70		

z Mean of greenhouse disease ratings for four replications at the Horticulture Field Laboratory, NCSU.
y Mean of field disease ratings taken at five weeks after planting for four replications at Castle Hayne NC in 2007.

Table 1.13. Downy mildew resistance components for plants tested with and without fungicide at Clinton, NC from 2008-2009[z].

Component:	Combined[y]		Chlorosis[x]		Necrosis[w]		Stunting[v]		Les. Size[u]	
Fungicide[t]:	None	TnPr	None	TnPr	None	TnPr	None	TnPr	None	TnPr
Mean:	4.6	3.7	4.5	3.3	5.5	4.3	4.3	3.6	6.7	6.9
Cultigen										
PI 605996	1.8	1.4	2.8	2.0	3.8	3.0	2.0	2.1	4.6	5.7
PI 618893	1.9	1.8	3.8	2.5	5.5	4.2	2.4	2.1	3.5	6.5
PI 330628	2.2	1.4	2.2	1.8	4.3	2.6	2.6	2.1	2.6	3.7
PI 605924	2.3	1.9	3.7	2.7	4.5	4.0	1.9	1.7	4.9	5.8
PI 605928	2.3	2.0	3.5	2.8	4.1	3.6	2.7	2.7	5.5	6.2
PI 197086	2.5	2.4	2.6	2.5	4.4	3.5	2.3	2.5	4.2	4.9
PI 197088	2.5	1.6	2.4	1.8	3.7	3.3	2.9	2.0	4.7	4.3
PI 432875	2.9	2.7	3.8	2.3	5.2	3.5	3.6	4.2	4.3	5.7
PI 618861	2.9	2.9	3.7	2.8	4.3	3.8	3.5	3.6	6.2	5.9
PI 606015	3.0	2.7	4.8	3.2	5.3	4.2	2.7	2.8	5.9	7.4
PI 606019	3.0	2.8	5.1	3.5	5.8	4.3	2.7	2.5	5.5	7.0
PI 606051	3.0	2.3	4.5	3.1	5.0	4.2	3.5	2.4	5.2	7.5
PI 432878	3.1	2.1	3.4	1.9	5.0	3.2	3.6	3.2	3.9	5.6
PI 605995	3.1	2.7	4.7	3.1	5.5	4.4	2.4	2.8	6.8	7.6
PI 606017	3.1	2.5	4.5	3.5	5.3	4.3	2.7	2.1	6.6	7.0
PI 618907	3.1	2.7	3.8	2.5	4.8	3.5	2.3	3.0	4.8	5.1
PI 432874	3.2	2.1	3.4	2.0	4.9	3.3	3.5	3.0	4.6	5.6
PI 432884	3.2	3.1	3.7	2.5	5.1	3.4	4.0	4.0	4.3	6.5
Ames 20089	3.3	1.9	3.1	2.1	4.0	2.8	2.9	2.5	3.8	4.6
PI 390267	3.3	2.5	3.5	2.5	4.9	3.9	4.3	2.8	4.1	5.1
PI 432876	3.3	3.2	2.9	2.5	4.0	3.4	5.6	5.4	4.6	5.6
PI 432882	3.3	4.0	3.6	2.7	4.4	4.1	4.2	3.5	5.3	6.2
PI 432885	3.3	2.8	3.2	2.0	4.2	3.4	4.3	3.1	5.4	5.0
PI 432886	3.3	2.3	3.5	2.3	5.1	3.9	4.4	3.4	4.1	5.7
PI 197085	3.5	2.4	2.9	2.3	5.0	3.6	3.0	2.8	4.4	4.8
PI 518849	3.7	2.6	4.4	2.1	5.6	3.9	3.6	3.1	4.7	6.2
PI 432877	3.8	2.8	3.2	2.1	3.8	3.1	5.7	4.2	6.2	4.4
PI 605932	3.8	3.3	3.1	2.4	4.9	4.0	5.0	3.9	7.5	7.1
PI 618937	3.8	2.3	4.6	2.6	5.7	3.8	3.1	2.8	5.4	7.9
Slice	3.8	3.5	3.0	2.9	5.5	4.6	4.3	3.2	7.8	8.1
PI 532523	3.9	3.4	5.8	3.5	5.6	4.7	2.7	2.2	4.8	5.7
PI 321008	4.0	3.2	3.8	2.9	4.5	3.3	4.5	3.8	7.6	8.0
PI 321009	4.0	3.7	3.6	3.0	4.1	3.7	4.7	5.1	7.7	8.1
PI 418963	4.0	3.8	4.4	3.4	5.1	4.4	4.4	4.1	6.4	8.1
PI 618922	4.0	3.5	3.7	2.6	4.7	3.9	4.3	3.6	4.6	5.9
PI 426170	4.1	3.0	3.6	2.2	5.8	3.9	3.1	2.9	8.3	7.7
PI 489753	4.1	4.0	4.2	3.6	4.7	4.3	3.9	4.3	8.1	7.7
TW-2	4.2	2.9	3.4	2.2	6.1	4.6	4.3	4.3	5.5	5.0
Model	4.3	3.5	3.7	2.7	5.2	3.7	4.2	3.7	8.0	7.2

Table 1.13 Continued

Poinsett 76	4.3	3.7	3.6	2.5	5.6	4.2	4.3	3.7	7.6	7.1
TW-3	4.3	2.5	3.3	2.2	6.0	4.5	5.0	3.9	5.0	6.5
M 21	4.4	3.3	3.2	2.1	4.9	3.2	5.6	5.1	5.9	6.1
PI 432859	4.4	3.0	4.8	3.7	5.9	5.0	3.9	2.8	5.6	6.2
NongChen#4	4.5	3.3	5.0	3.4	5.6	4.1	4.0	2.7	7.2	7.5
PI 511819	4.5	4.6	5.5	4.9	5.4	4.7	3.5	3.8	8.4	8.1
PI 618931	4.5	4.4	3.6	3.0	4.7	3.8	4.1	4.2	7.9	7.8
Ames 2354	4.6	3.0	3.5	2.5	4.9	3.2	5.1	3.6	6.4	7.2
SC 50	4.6	2.8	3.5	2.4	5.4	4.0	3.8	2.8	7.8	7.4
Heidan#1	4.7	2.6	5.0	3.0	5.2	3.7	4.8	2.9	5.4	6.7
PI 605929	4.7	3.2	3.7	2.6	5.4	3.7	5.0	4.0	8.1	7.2
Ames 2353	4.8	2.9	3.6	2.2	5.1	3.1	4.2	3.8	7.4	6.9
Homegreen #2	4.8	3.4	3.8	2.7	5.1	3.5	5.8	5.2	6.9	8.6
WI 2757	4.9	4.6	3.2	2.6	3.6	3.0	6.7	7.3	8.6	8.0
Gy 4	5.0	3.9	3.8	2.9	5.6	4.4	4.1	3.5	7.3	7.3
PI 267741	5.0	3.8	4.3	3.5	4.9	4.0	5.2	5.2	7.6	7.6
PI 618955	5.0	4.1	5.7	3.7	5.8	4.6	4.2	3.6	8.3	7.8
Polaris	5.1	3.3	2.9	2.4	4.4	3.9	6.4	4.8	8.7	8.4
Calypso	5.2	4.2	4.0	3.2	5.4	4.6	4.9	2.9	7.5	8.0
Marketmore 76	5.2	3.5	4.8	3.5	5.7	4.3	5.1	4.1	8.3	7.5
PI 618944	5.2	3.8	6.4	3.7	6.5	4.3	3.2	3.0	8.3	6.2
PI 179676	5.3	4.2	5.8	4.7	6.2	5.2	4.2	2.7	8.6	8.4
SC 10	5.3	3.5	4.0	2.4	5.4	3.7	4.9	3.8	6.7	6.3
TW-1	5.3	3.5	5.0	3.6	6.6	4.5	5.9	4.8	5.5	7.0
WI 2238	5.3	3.3	3.5	3.1	5.1	4.1	4.6	3.3	7.6	7.4
Ashley	5.4	4.0	5.2	3.4	5.8	4.1	4.9	4.5	7.9	8.3
Sumter	5.4	4.3	4.6	3.4	6.5	4.9	4.4	3.7	7.7	7.4
Dasher II	5.5	4.0	5.2	3.7	5.8	5.1	3.9	2.8	8.4	8.1
PI 508455	5.5	3.8	5.3	3.2	6.4	4.5	4.5	3.5	5.3	6.3
TW-4	5.7	3.6	4.5	3.6	6.4	5.1	6.3	5.1	7.0	6.0
Mariner H-423	5.8	3.8	4.8	2.7	6.1	4.3	4.9	3.0	7.5	7.1
Straight 8	6.6	6.2	6.5	5.5	7.1	6.1	4.9	4.1	9.0	8.7
PI 525151	6.8	6.2	6.6	5.9	7.3	6.0	4.9	4.0	8.7	7.3
Wis.SMR 18	6.8	6.2	6.9	6.2	7.1	6.4	5.1	3.2	8.5	7.7
Coolgreen	7.1	6.5	6.6	5.9	7.2	5.6	6.1	4.0	8.3	7.9
PI 218199	7.1	6.5	6.6	6.1	7.1	6.2	5.5	4.2	9.0	8.0
PI 171601	7.3	6.8	7.0	6.1	7.4	6.5	5.4	4.2	9.0	8.0
PI 458851	7.3	5.8	6.9	5.7	7.0	6.0	5.5	3.3	9.0	8.0
PI 211983	7.4	6.2	6.9	6.0	7.3	5.9	6.1	4.1	8.8	8.3
PI 176523	7.5	6.6	6.9	5.9	7.0	5.9	6.1	4.8	8.5	8.8
PI 344350	7.5	6.5	7.1	5.9	7.3	5.8	5.7	4.5	8.9	8.3
Ames 25699	7.6	6.9	7.1	6.5	7.5	6.4	5.9	4.0	8.8	8.0
Ames 23009	7.8	6.5	7.0	5.7	7.4	6.2	5.6	4.0	7.8	8.0
Ames 19225	7.9	6.4	6.4	4.5	7.5	6.0	7.3	6.5	8.4	7.6
LSD (5%)	0.3	0.3	0.5	0.4	0.5	0.4	0.8	0.7	1.0	1.0

z Data are from 2 years and 4 replications.
y Combined is mean of best ratings for each year based on F-value.
x Data are means of chlorosis ratings for 2008-2009.

Table 1.13 Continued

w Data are means of necrosis ratings for in 2008-2009.
v Data are means of stunting ratings for in 2008-2009.
u Data are means of lesion size ratings for 2008-2009.
t Weekly application of Previcure Flex and Mancozeb alternating with Tanos and Bravo.

Table 1.14. Yield traits for plants tested with and without fungicide at Clinton, NC from 2008-2009[z].

Component:	Tot. Mg/ha[y]		Mk Mg/ha[x]		% Early[w]		kg/Fruit[v]	
Fungicide[u]:	None	TnPr	None	TnPr	None	TnPr	None	TnPr
Mean:	7.2	15.9	5.1	13.4	27.8	23.8	0.31	0.36
Cultigen								
PI 618907	25.8	24.9	18.1	19.1	32.0	28.0	0.53	0.51
PI 432885	25.8	36.3	20.1	28.4	5.0	20.0	0.53	0.41
PI 197086	21.2	18.3	20.9	18.3	21.0	8.0	0.22	0.26
Ames 20089	20.9	43.6	16.2	40.9	9.0	15.0	0.45	0.61
PI 330628	20.4	33.1	20.1	31.7	6.0	4.0	0.28	0.31
PI 432882	18.8	30.6	15.5	29.3	4.0	17.0	0.37	0.44
PI 618937	17.6	33.9	9.9	28.3	50.0	22.0	0.31	0.51
PI 432874	14.7	21.1	11.8	18.5	13.0	5.0	0.31	0.52
PI 432878	14.6	16.7	10.6	14.3	15.0	15.0	0.34	0.28
PI 532523	14.3	31.8	8.3	26.6	45.0	27.0	0.28	0.28
PI 605924	13.8	22.5	12.3	18.8	8.0	8.0	0.40	0.41
PI 606015	13.6	26.6	12.7	21.7	2.0	2.0	0.72	0.96
PI 432875	12.8	16.6	7.3	14.8	20.0	8.0	0.25	0.33
PI 518849	12.7	18.9	9.0	16.1	31.0	8.0	0.32	0.47
PI 197088	12.7	23.8	12.2	23.5	15.0	1.0	0.27	0.36
PI 432877	12.4	32.3	10.3	28.7	0.0	10.0	0.40	0.43
PI 605995	12.3	21.2	11.0	19.1	9.0	1.0	0.55	0.96
PI 197085	11.8	15.3	11.7	13.6	22.0	7.0	0.27	0.33
PI 606019	11.6	30.4	10.6	26.4	1.0	8.0	0.45	0.59
PI 418963	11.3	15.0	5.6	13.1	17.0	25.0	0.46	0.55
PI 508455	10.3	25.6	7.3	20.9	59.0	48.0	0.21	0.31
PI 511819	10.1	13.7	7.5	12.1	38.0	41.0	0.33	0.47
PI 390267	10.1	17.3	7.4	16.0	20.0	9.0	0.37	0.49
PI 432859	9.7	24.8	5.1	19.1	32.0	28.0	0.34	0.60
PI 605928	9.6	16.6	9.1	14.6	5.0	6.0	0.56	0.58
PI 618861	9.5	16.0	5.7	14.0	7.0	16.0	0.39	0.46
PI 432884	9.5	11.1	5.0	10.4	2.0	6.0	0.28	0.30
PI 426170	9.5	21.1	3.1	16.3	25.0	23.0	0.26	0.30
TW-2	9.4	7.8	6.2	6.3	88.0	67.0	0.17	0.13
PI 618922	8.5	24.4	7.1	22.3	50.0	22.0	0.37	0.67
PI 432886	7.5	20.3	6.1	17.9	0.0	7.0	0.33	0.45
PI 606017	7.2	27.9	6.6	23.5	0.0	8.0	0.54	0.50
Mariner H-423	6.9	20.3	5.5	17.4	76.0	42.0	0.22	0.26
Ames 2353	6.9	10.3	4.5	8.9	30.0	19.0	0.22	0.25
PI 432876	6.6	14.0	6.1	13.9	4.0	1.0	0.41	0.46
Model	6.6	15.0	3.6	13.1	29.0	32.0	0.18	0.27
Heidan#1	6.5	19.6	4.2	16.3	7.0	4.0	0.27	0.40
NongChen#4	6.4	30.1	5.0	23.6	6.0	15.0	0.23	0.30
TW-3	6.1	8.8	2.3	6.6	92.0	66.0	0.16	0.17
SC 50	6.0	16.4	2.5	14.2	21.0	28.0	0.13	0.25

Table 1.14 Continued

PI 489753	5.9	10.4	5.0	10.3	1.0	1.0	0.55	0.66
Gy 4	5.6	20.3	2.6	15.6	73.0	51.0	0.14	0.30
PI 618893	5.3	5.1	1.8	1.2	19.0	17.0	0.26	0.26
PI 605996	5.3	8.4	5.2	8.3	0.0	0.0	0.31	0.45
TW-1	4.9	5.4	3.8	3.5	89.0	64.0	0.21	0.16
Ames 2354	4.8	13.1	2.6	11.0	24.0	20.0	0.39	0.28
PI 605929	4.7	10.2	2.9	9.1	22.0	13.0	0.18	0.20
M 21	4.2	6.6	3.1	5.7	32.0	28.0	0.15	0.18
PI 618944	4.1	16.3	2.2	14.2	29.0	19.0	0.23	0.46
SC 10	4.0	13.2	1.7	11.1	42.0	31.0	0.11	0.25
WI 2238	3.7	27.2	3.3	26.2	17.0	10.0	0.17	0.32
TW-4	3.7	5.3	1.8	4.2	86.0	73.0	0.17	0.14
Poinsett 76	3.7	12.0	1.1	10.2	32.0	25.0	0.16	0.27
PI 606051	3.7	26.1	2.7	23.8	0.0	9.0	0.27	0.46
Calypso	3.5	21.2	2.0	17.2	35.0	41.0	0.24	0.26
Dasher II	2.9	23.1	1.7	19.6	16.0	39.0	0.21	0.27
PI 321008	2.6	1.1	1.5	1.0	0.0	0.0	0.70	0.60
Slice	2.5	16.6	1.0	12.7	8.0	22.0	0.15	0.28
Sumter	2.2	14.3	0.9	11.9	20.0	37.0	0.15	0.26
PI 605932	2.1	10.8	1.1	8.7	20.0	17.0	0.18	0.20
PI 618931	1.9	12.1	0.5	9.6	39.0	74.0	0.17	0.32
PI 179676	1.7	12.4	0.5	9.6	0.0	6.0	0.36	0.35
PI 618955	1.6	9.5	1.2	8.4	50.0	22.0	0.26	0.37
Ashley	1.5	6.5	0.6	5.8	7.0	8.0	0.20	0.22
WI 2757	0.7	2.8	0.4	2.1	19.0	2.0	0.20	0.24
Polaris	0.7	2.6	0.2	2.0	0.0	2.0	0.41	0.23
PI 267741	0.7	3.1	0.3	3.1	0.0	35.0	0.54	0.34
PI 525151	0.6	7.9	0.1	5.4	34.0	50.0	0.14	0.26
PI 218199	0.5	6.1	0.3	4.8	48.0	71.0	0.18	0.32
Wis.SMR 18	0.4	11.2	0.1	7.7	40.0	37.0	0.14	0.22
Marketmore 76	0.4	3.0	0.3	2.9	0.0	2.0	0.29	0.24
Ames 23009	0.3	2.1	0.1	1.4	55.0	62.0	0.27	0.21
Ames 19225	0.3	4.2	0.0	2.9	90.0	51.0	0.02	0.20
PI 344350	0.2	2.1	0.1	1.9	100.0	69.0	0.14	0.24
Coolgreen	0.2	5.9	0.0	4.7	0.0	53.0	.	0.26
PI 321009	0.1	4.9	0.0	2.9	0.0	0.0	.	0.48
PI 176523	0.1	1.3	0.0	0.9	100.0	33.0	.	0.34
PI 171601	0.1	7.3	0.0	6.3	100.0	57.0	.	0.26
Homegreen #2	0.1	3.0	0.0	2.5	0.0	0.0	.	0.40
Straight 8	0.0	8.0	0.0	5.0	100.0	38.0	0.05	0.25
PI 458851	0.0	5.1	0.0	2.8	0.0	19.0	.	0.25
PI 211983	0.0	0.9	0.0	0.5	.	11.0	.	0.32
Ames 25699	0.0	6.1	0.0	4.3	100.0	87.0	.	0.20
LSD (5%)	5.1	7.0	4.1	6.6	19	15	0.12	0.10

z Data are from 2 years and 4 replications with 2 harvests each.
y Total yield measured as Mg/ha.
x Marketable (non-cull) yield measured as Mg/ha.
w Percent early fruit is data from harvest #1 only.

Table 1.14 Continued

v Mean weight per fruit in kg/fruit.

u Weekly application of Previcure Flex and Mancozeb alternating with Tanos and Bravo.

Table 1.15. Yield traits for plants tested with and without fungicide at Clinton, NC in 2009[z].

Component:	Tot. Mg/ha[y]		Mk Mg/ha[x]		% Early[w]		kg/Fruit[v]	
Fungicide[u]:	None	TnPr	None	TnPr	None	TnPr	None	TnPr
Mean:	11.4	27.4	8.5	23.4	24.1	27.6	0.35	0.42
<u>Cultigen</u>								
PI 618907	47.0	49.0	34.6	37.5	29	29	0.60	0.57
PI 197086	36.7	32.4	36.1	32.4	9	12	0.30	0.33
PI 330628	35.4	62.7	34.7	60.0	6	4	0.36	0.43
PI 618937	30.2	64.6	16.5	55.0	36	31	0.36	0.60
PI 432874	27.7	41.1	22.2	36.5	10	8	0.38	0.59
PI 606015	26.6	53.2	25.1	43.4	1	2	0.84	0.96
PI 605924	25.9	42.7	23.2	36.9	1	2	0.52	0.61
Ames 418962	25.9	44.9	20.1	35.5	25	21	0.57	0.64
PI 432885	25.8	36.3	20.1	28.4	5	20	0.53	0.41
PI 432878	25.7	32.5	19.1	28.0	10	22	0.37	0.35
PI 532523	25.5	62.5	14.7	52.9	39	27	0.34	0.39
Gy57u	24.8	43.3	8.8	30.3	20	27	0.46	0.56
PI 518849	24.4	35.5	17.2	31.9	11	14	0.38	0.53
PI 605995	23.5	42.5	21.4	38.2	0	1	0.66	0.96
PI 197088	23.3	47.0	22.7	46.4	3	2	0.41	0.51
PI 606019	21.4	60.7	20.2	52.9	0	10	0.60	0.59
PI 418963	21.1	29.8	10.5	26.2	17	33	0.53	0.55
Ames 20089	20.9	43.6	16.2	40.9	9	15	0.45	0.61
PI 432875	20.7	32.5	11.7	29.1	14	12	0.35	0.43
PI 197085	20.3	29.1	20.0	25.9	12	5	0.37	0.44
PI 390267	19.8	33.9	14.6	31.4	11	13	0.45	0.55
PI 432859	19.3	48.8	10.2	38.2	15	22	0.34	0.60
PI 605928	19.2	32.7	18.2	28.8	7	8	0.56	0.63
PI 508455	19.1	46.0	14.3	38.2	60	49	0.33	0.42
PI 432882	18.8	30.6	15.5	29.3	4	17	0.37	0.44
PI 511819	18.3	27.3	13.9	24.2	34	41	0.38	0.47
PI 618861	17.7	31.4	11.0	27.5	11	20	0.41	0.47
PI 618922	16.8	48.9	14.1	44.7	38	22	0.44	0.67
PI 432884	16.8	21.4	8.9	20.1	1	11	0.33	0.37
PI 426170	14.5	38.5	5.3	31.1	33	38	0.31	0.45
PI 606017	14.2	53.8	13.2	45.2	0	3	0.54	0.62
PI 432886	12.6	40.1	11.8	35.9	0	10	0.40	0.45
Heidan#1	12.6	39.0	8.2	32.4	10	5	0.37	0.49
Ames 426169	12.5	54.2	8.1	38.8	17	35	0.37	0.47
Ames 2353	12.5	18.9	8.9	16.9	36	36	0.32	0.33
PI 432877	12.4	32.3	10.3	28.7	0	10	0.40	0.43
PI 489753	11.8	20.7	10.0	20.6	1	1	0.55	0.66
NongChen#4	11.4	59.8	8.7	47.0	10	22	0.28	0.42
Model	10.7	25.8	6.5	22.3	45	54	0.23	0.33
Mariner H-423	10.3	35.6	9.5	31.3	84	61	0.28	0.37

Table 1.15 Continued

PI 605996	10.0	15.8	9.8	15.8	0	0	0.38	0.51
SC 50	9.8	29.5	4.8	25.7	29	48	0.18	0.34
Ames 2354	8.5	23.5	5.1	20.8	20	40	0.39	0.36
PR 39	7.9	10.9	5.3	10.2	23	15	0.21	0.33
Gy 4	7.7	31.1	4.1	23.9	68	66	0.19	0.38
PI 618944	7.3	31.4	4.4	27.8	36	24	0.23	0.50
PI 432876	6.6	14.0	6.1	13.9	4	1	0.41	0.46
SC 10	6.1	22.6	2.4	18.9	41	50	0.10	0.31
PI 606051	6.0	51.7	4.9	47.4	1	13	0.30	0.55
M 21	5.6	5.2	4.5	4.4	29	40	0.18	0.18
PI 605929	5.3	19.2	3.4	17.1	14	26	0.24	0.28
PI 321008	5.1	2.0	3.0	2.0	0	0	0.70	0.60
Dasher II	5.0	41.7	2.8	36.0	22	54	0.25	0.38
Calypso	4.4	35.2	3.3	28.6	19	51	0.27	0.34
Slice	4.4	30.1	1.9	23.6	0	29	0.19	0.35
PI 618931	3.7	24.1	1.0	19.2	39	74	0.17	0.32
WI 2238	3.7	27.2	3.3	26.2	17	10	0.17	0.32
Poinsett 76	3.4	21.3	1.3	18.4	50	43	0.19	0.36
Sumter	3.2	24.3	1.6	20.4	28	71	0.24	0.37
PI 618955	2.8	16.4	2.3	14.5	50	21	0.36	0.40
Ashley	2.3	12.0	1.0	10.5	13	14	0.20	0.26
PI 605932	2.2	16.9	1.1	13.8	0	26	0.26	0.26
PI 179676	1.8	22.8	1.0	17.9	0	11	0.36	0.41
PI 525151	1.2	14.7	0.1	10.8	42	65	0.14	0.30
PI 267741	1.2	6.1	0.6	6.1	0	2	0.54	0.48
Polaris	1.2	4.7	0.4	3.8	0	4	0.41	0.26
PI 218199	1.0	12.2	0.6	9.6	95	71	0.27	0.32
H-19	1.0	2.3	1.0	2.3	0	0	0.91	0.16
Marketmore 76	0.9	5.0	0.6	5.0	0	1	0.29	0.26
WI 2757	0.7	2.8	0.4	2.1	19	2	0.20	0.24
Wis.SMR 18	0.6	20.4	0.1	14.5	33	70	0.14	0.31
Ames 23009	0.5	4.1	0.3	2.9	55	77	0.27	0.21
Ames 19225	0.5	8.1	0.0	5.7	83	87	0.02	0.21
Ashe	0.5	6.4	0.0	5.8	0	4	.	0.36
Coolgreen	0.4	10.7	0.0	9.1	0	64	.	0.27
PI 344350	0.3	3.4	0.1	3.1	100	96	0.14	0.26
Homegreen #2	0.3	6.0	0.0	5.0	0	0	.	0.40
PI 321009	0.1	9.9	0.0	5.7	0	0	.	0.48
PI 176523	0.1	2.5	0.0	1.8	100	50	.	0.34
PI 171601	0.1	14.2	0.0	12.3	100	85	.	0.29
PI 458851	0.0	9.6	0.0	5.2	0	23	.	0.28
PI 211983	0.0	1.7	0.0	1.1	.	11	.	0.32
Ames 25699	0.0	11.2	0.0	8.4	100	85	.	0.21
Straight 8	0.0	16.0	0.0	10.1	100	38	0.05	0.25
Poinsett	0.0	3.4	0.0	2.8	.	6	.	0.20
LSD (5%)	12.1	17.7	10.3	16.0	27.8	19.7	0.18	0.13

z Data are from 4 replications with 2 harvests each.
y Total yield measured as Mg/ha.

Table 1.15 Continued
x Marketable (non-cull) yield measured as Mg/ha.
w Percent early fruit is data from harvest #1 only.
v Mean weight per fruit in kg/fruit.
u Weekly application of Previcure Flex and Mancozeb alternating with Tanos and Bravo.

Table 1.16. Pearson product-moment correlation coefficients (above diagonal) and Spearman rank correlation coefficients (below diagonal) of mean downy mildew chlorosis ratings in environments (Year x Location) from 2007 to 2009[z].

	Environment (Year x Location)							
	2007			2008		2009		
	C.Hayne[y]	HFL[x]	Bang.[w]	Clint.[v]	Clint.-F[u]	C.Hayne[t]	Clint[s].	Clint.-F[r]
2007								
C. Hayne		0.64***	0.74***	0.85***	0.76***	0.83***	0.85***	0.80***
HFL	0.61***		0.60***	0.71***	0.78***	0.73***	0.69***	0.72***
Bangalore	0.68***	0.44**		0.73***	0.78***	0.84***	0.83***	0.86***
2008								
Clinton	0.85***	0.61***	0.51***		0.84***	0.79***	0.81***	0.78***
Clnt-Fung	0.81***	0.59***	0.57***	0.80***		0.86***	0.80***	0.82***
2009								
C. Hayne	0.82***	0.63***	0.74***	0.72***	0.80***		0.93***	0.89***
Clinton	0.83***	0.61***	0.78***	0.76***	0.76***	0.90***		0.93***
Clnt-Fung.	0.76***	0.56***	0.80***	0.68***	0.69***	0.84***	0.90***	

z Data are from four replications using combined best ratings based on F value.
y Data are mean of all chlorosis ratings from Castle Hayne, NC, in 2007.
x Data are mean of all chlorosis ratings from Horticulture Field Laboratory, NCSU, Raleigh, NC, in 2007.
w Data are mean of all chlorosis ratings from Bangalore, India, in 2007.
v Data are mean of all chlorosis ratings from Clinton, NC, in 2008.
u Data are mean of all chlorosis ratings with fungicide from Clinton, NC, in 2008.
t Data are mean of all chlorosis ratings from Castle Hayne, NC, in 2009.
s Data are mean of all chlorosis ratings from Clinton, NC, in 2009.
r Data are mean of all chlorosis ratings with fungicide from Clinton, NC, in 2009.
*, **,**Significant at 0.05, 0.01 and 0.001, respectively

Table 1.17. Pearson product-moment correlation coefficients (above diagonal) and Spearman rank correlation coefficients (below diagonal) of yield data from Clinton, NC, with and without fungicide application in 2008 and 2009[z].

	Environment (Year x Location)			
	2008		2009	
	Clinton[y]	Clinton-F[x]	Clinton[w]	Clinton-F[v]
Total Mg/ha				
2008				
Clinton		0.63***	0.60***	0.47***
Clinton-Fung.	0.63***		0.01	0.12
2009				
Clinton	0.65***	0.16		0.75***
Clinton-Fung.	0.56***	0.19	0.81***	
Marketable Mg/ha				
2008				
Clinton		0.47***	0.68***	0.49***
Clinton-Fung.	0.51***		0.03	0.08
2009				
Clinton	0.69***	0.16***		0.74***
Clinton-Fung.	0.59***	0.15***	0.82	
Percent early fruit				
2008				
Clinton		0.29 *	0.52***	0.41***
Clinton-Fung.	0.28*	0.32 *	0.48***	
2009				
Clinton	0.52***	0.32		0.74***
Clinton-Fung.	0.31 *	0.26	0.51***	

z Data are from 2 harvests and four replications. Locations with fungicide received weekly application of Previcure Flex and Mancozeb alternating with Tanos and Bravo.
y Data are from Clinton, NC, in 2008 without fungicide.
x Data are from Clinton, NC, in 2008 with fungicide.
w Data are from Clinton, NC, in 2009 without fungicide.
v Data are from Clinton, NC, in 2009 without fungicide.
*, **,**Significant at 0.05, 0.01 and 0.001, respectively

Table 1.18. Pearson product-moment correlation coefficients (above diagonal) and Spearman rank correlation coefficients (below diagonal) of disease traits in North Carolina and India, 2007-2009[z].

Trait	Chlorosis[y]	Necrosis[x]	Stunting[w]
Chlorosis		0.87***	0.35***
Necrosis	0.81***		0.42***
Stunting	0.34***	0.36***	

z Data from four replications.
y Data are mean of all chlorosis ratings in 2007-2009.
x Data are mean of all necrosis ratings in 2007-2009.
w Data are mean of all stunting ratings in 2007-2009.
*, **,**Significant at 0.05, 0.01 and 0.001, respectively.

Table 1.19. Pearson product-moment correlation coefficients (above diagonal) and Spearman rank correlation coefficients (below diagonal) of disease traits in Clinton, North Carolina with and without fungicide in 2008-2009[z].

Trait	Chlorosis[y]	Necrosis[x]	Stunting[w]	Lesion Size[v]
Chlorosis		0.90***	0.37***	0.65***
Necrosis	0.83***		0.34***	0.61***
Stunting	0.34***	0.30***		0.53***
Lesion Size	0.69***	0.62***	0.56***	

z Data are from four replications using combined best ratings based on F value.
y Data are mean of all chlorosis ratings.
x Data are mean of all necrosis ratings.
w Data are mean of all stunting ratings.
v Data are mean of all lesion size ratings.
*, **,**Significant at 0.05, 0.01 and 0.001, respectively

Table 1.20. Variability of PI accessions and inbred lines over environments and reps: Chlorosis[z].

Year	Location	Rep	PI 197088	PI 605996	'M 21'	'Poinsett 76'	'Wis.SMR 18'
2007	Bangalore[y]	1	1	1	1	3	9
		2	1	1	1	1	9
		3	7	1	7	1	9
		4	5	1	2	7	9
	Castle Hayne[x]	1	1	2	1	3	6
		2	1	2	3	2	5
		3	2	1	3	7	6
		4	3	2	3	3	6
	HFL[w]	1	2	5	3	0	2
		2	4	1	1	2	3
		3	0	2	3	4	4
		4	1	2	1	-	4
2008	Clinton, NC-F[v]	1	2	2	2	2	4
		2	2	1	2	2	6
		3	1	2	2	1	5
		4	1	2	1	2	6
	Clinton, NC[u]	1	4	3	4	4	7
		2	4	3	4	4	6
		3	2	6	4	3	7
		4	2	4	4	3	7
2009	Castle Hayne[t]	1	1	3	5	2	6
		2	1	3	5	3	7
		3	2	3	3	4	7
		4	2	3	3	4	6
	Clinton, NC-F[s]	1	1	1	3	3	8
		2	1	1	2	5	8
		3	1	2	3	4	9
		4	1	1	3	4	8
	Clinton, NC[r]	1	3	1	3	5	8
		2	1	2	3	5	8
		3	1	1	4	3	7
		4	1	2	3	4	8

z Data are chlorosis ratings only
y Data are from a single rating in Bangalore, India, in 2007.
x Data are from a single rating in Castle Hayne, NC, in 2007.
wData are from a single rating at Horticulture Field Laboratory, NCSU, Raleigh, NC, in 2007.
v Data are from a single rating with fungicide in Clinton, NC, in 2008.
u Data are from a single rating in Clinton, NC, in 2008.
t Data are from a single rating in Castle Hayne, NC, in 2009.
s Data are from a single rating with fungicide in Clinton, NC, in 2009.
r Data are from a single rating in Clinton, NC, in 2009.

Chapter Two

Resistance of cucumber (Cucumis sativus L.) cultivars to downy mildew caused by (Pseudoperonospora cubensis (Berk. and Curt.) Rostow.)

Adam D. Call, Kaori Ando, Todd C. Wehner, and Rebecca Grumet

Resistance of Current Cucumber Cultivars to the New Downy Mildew

Adam D. Call, Adam D. Criswell and Todd C. Wehner [1]

Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Kaori Ando and Rebecca Grumet [2]

Department of Horticulture, Michigan State University, East Lansing, MI 48824

Received for publication _______________. Accepted for publication _______________. The use of trade names in this publication does not imply endorsement by the North Carolina Agricultural Research Service of the products named, or criticism of similar ones not mentioned.. Direct correspondence to Todd Wehner (Todd_Wehner@NCSU.Edu).

[1] Graduate research assistant, former graduate research assistant (currently assistant breeder, Syngenta) and professor, respectively. The authors gratefully acknowledge the technical assistance of Tammy L. Ellington. The authors thank the USDA North Central Regional Plant Introduction Station at Ames, Iowa for kindly providing seeds for the study.

[2] Graduate research assistant and professor, respectively. The authors thank MSU-GREEEN for support of this project, Randy Hugo for providing inoculum, and Dan Raba, Matt Duncan, Ron Gnagey, and Mitch Fabus for their labor.

Additional index words: Cucumis sativus, Disease, *Pseudoperonospora cubensis*

Abstract

Downy mildew, a foliar disease caused by the oomycete *Pseudoperonospora cubensis* (Berk. and Curt.) Rostow. is one of the most destructive pathogens of cucurbits. Prior to 2004, resistance in cultivars was sufficient to grow a successful crop without the use of fungicides. Currently, resistant cultivars are available but are not fully effective against the new strain of downy mildew, and yield losses are high without the use of fungicides. The objective of this experiment was to identify cultivars having high yield and resistance to the new downy mildew. The experiment had 86 cultigens, three locations (Clinton and Castle Hayne, NC, and Bath, MI) and three years (2007 to 2009) and 4 replications. Plots were rated weekly on a 0 to 9 (0=none, 1-2=trace, 3-4=slight, 5-6=moderate, 7-8=severe, 9=dead).

Mean ratings for downy mildew leaf damage ranged from 2.9 to 5.7 in Michigan in 2008 and 2009, and from 2.5 to 5.4 in North Carolina. The ten most resistant cultigens in Michigan in 2008 and 2009 were 'Fanfare', M 21, 'Cross Country', 'Vlasset', 'Marketmore 76', 'Pony', 'MacArthur', 'Eureka', and 'Stallion'. The most resistant cultigens in North Carolina locations over 2007, 2008, and 2009 were 'Wautoma', M 21, 'Picklet', 'Poinsett 76', 'NC-Davie', 'Pony', 'Stonewall', 'Cates', 'HM 82', and 'Excel'. The top yielding cultigens were WI 1983, Nun 5054 PU F1, Nun 5052 PU F1, Nun 5053 PU F1, 'Cates', 'Starex', 'Pony', 'Vlasspear', 'Classy', and 'Fancipak'. In generall, high yielding cultigens tended to be more resistant than lower yielding cultigens. None of the cultigens tested in this study showed a high level of resistance, although differences in cultigens resistance still exist. Until new resistance becomes available, growers would likely benefit by growing those cultigens that we have shown to perform well for disease and yield.

Introduction

Downy mildew, caused by the oomycete pathogen *Pseudoperonospora cubensis* (Berk. And Curt) Rostov, is a major foliar disease of cucumber (*Cucumis sativus* L.) (Palti and Cohen, 1980). Studies on the host range of *P. cubensis* indicate approximately 20 genera, including 50 species in the Cucurbitaceae, to be hosts, of which 19 species are in *Cucumis* (Palti and Cohen, 1980; Lebeda, 1992; Lebeda and Widrlechner, 2003). Other economically important hosts of *P. cubensis* are melon (*Cucumis melo* L.), watermelon

(*Citrullus lanatus* (Thunb.) Matsum. & Nakai), and squash (*Cucurbita* spp.) (Whitaker and Davis, 1962).

Worldwide, cucumber is the fourth most widely grown vegetable crop in the world after tomato (*Lycopersicon esculentum* Mill.), cabbage (*Brassica oleracea* var. *capitata* L.), and onion (*Allium cepa* L.) (Tatlioglu, 1993). In 2008 in the United States, 61,399 hectares of cucumbers for processing and fresh market were grown, with a value of $421 million. In North Carolina, 7,284 hectares were planted with a value of $25 million (USDA, 2009).

Symptoms of cucumber downy mildew appear mostly on the foliage. Infection first appears as small, water-soaked lesions on the underside of leaves. Initially, lesions may be round in shape, becoming angular, since they are bound by leaf veins, and turning chlorotic to varying degrees. Chlorotic lesions may turn necrotic. Eventually the entire leaf becomes necrotic and dies. Bains (1991) described four categories of lesion types: 1=faded green to dull yellow lesions, size restricted, slow necrosis; 2=yellow spots or flecks, non-angular, slow growing, slow necrosis; 3=bright yellow, large, angular, fast growing, susceptible type, high sporulation; 4=necrotic spots or flecks, non-angular, little chlorosis, hypersensitive response (HR) type. Lesions for most cultivars we have observed are best described as category 3, the determinate pickling type inbred line M 21 is category 1, and 'Heidan #1' is category 2. Symptoms vary depending on the susceptibility of the cultigen. The most resistant cultigens exhibit a HR with small necrotic or chlorotic flecks and sparse sporulation, while the most susceptible cultigens die after a few weeks, and have leaves that are sporulating heavily. Sporulation occurs on the undersides of the leaves, appearing as gray to black specks that may completely cover a region of tissue. The name downy mildew comes from the description of sporulation on the undersides of leaves.

Downy mildew infects via windblown sporangia that land on the leaf surface. In cooler production regions, *P. cubensis* is an obligate biotroph, surviving only on living host tissue. In production regions having a mild winter, such as southern Florida, overwintering occurs on wild and cultivated cucurbits (Bains and Jhooty, 1976). Overwintering is also possible in greenhouses. Hausbeck (2009) reported *P. cubensis* on greenhouse cucumber in Ontario, Canada in 2006 and 2007. Environmental conditions affect overwintering capacity as well as disease development and intensity. Rain, dew, and irrigation supply adequate leaf moisture, required for sporangia to germinate. Under optimum temperature, infection can occur with only two hours of leaf wetting (Cohen, 1977). The level of infection for compatible reactions is a result of the combination of time, moisture, temperature, and inoculum concentration. Inoculum concentration is affected by many factors such as weather, location, proximity to source, cultivar resistance, fungicide effectiveness, and area affected.

Currently, high yield and quality in the presence of downy mildew is achieved using multiple fungicide applications. Most of the currently grown cultivars have some resistance to downy mildew. Prior to 2004, this resistance was sufficient to control the disease, and downy mildew was only a minor problem on cucumber. St. Amand and Wehner (1991) estimated an average 2.9% yield loss per year from 1982 to 1988. The pathogen resurged as a major problem in 2004, causing a 40% loss for cucumber growers (Colucci et al., 2006).

Since then, downy mildew has continued to be a major disease of cucumber in the eastern United States, where conditions are favorable for disease. There are currently no cultivars having resistance at a level equal to that seen prior to 2004. However, differences in resistance among cultivars do exist, ranging from moderately resistant to highly susceptible. By growing cultivars rated higher for resistance, growers may be able to reduce fungicide applications and production costs. The goal of this study was to determine the resistance of past and currently grown cultivars to the new strain of downy mildew, present since 2004, and cultivars with high yield under disease epidemic, defined as tolerant. We also looked at specific components of overall resistance: chlorosis and necrosis, stunting, lesion size, and sporulation. Components were not rated at all years and locations.

Materials and Methods

Location and Seed Sources

Experiments were conducted at the Horticultural Crops Research Stations in Clinton and Castle Hayne, North Carolina and at Muck Soil Research Farm in Bath, Michigan. Due to low seed availability of some cultivars, some substitutions were made each year. Cultivars tested include cultigens from Monsanto/Seminis, Clause/Harris Moran, Bayer/Nunhems, Bejo, Western, Baker, United Genetics, NC State University, and check cultivars. The checks were 23 cucumber cultivars differing for downy mildew resistance used to evaluate severity of disease. Check cultivars were ‘Ashley’ (Clemson Univ.) ‘Calypso’ (North Carolina State Univ.), ‘Coolgreen’ (Asgrow), ‘Dasher II’ (Seminis), Gy 4 (North Carolina

State Univ.), 'Heidan #1' (PR China), ‘Homegreen #2’ (USDA-Wisconsin), H-19 (Univ. Arkansas), LJ 90430 (USDA, La Jolla), M 21 (North Carolina State Univ.), M 41 (North Carolina State Univ.), ‘Marketmore 76’ (Cornell Univ.), ‘NongChen #4’ (PR China), ‘Poinsett 76’ (Cornell Univ.), ‘Slice’ (Clemson Univ.), ‘Straight 8’ (National Seed Storage Laboratory), ‘Sumter’ (Clemson Univ.), ‘Tablegreen 72’ (Cornell Univ.) ‘TMG-1’ (PR China), WI 2238 (USDA-Wisconsin), WI 2757 (USDA-Wisconsin), WI 4783 (USDA-Wisconsin), and ‘Wisconsin SMR 18’ (Wisconsin AES).

In North Carolina, all cucumbers were grown using recommended horticultural practices as summarized by Schultheis (1990). Fertilizer was incorporated before planting at a rate of 90-39-74 kg/ha (N-P-K) with an additional 34 kg N/ha applied at the vine-tip-over stage (four to six true leaves). Plots were planted after downy mildew was reported in the area. The field was surrounded by border rows, and spreader rows were spaced every 9 rows in the field, planted to a susceptible check. Plots 1.5 m long were hand-seeded on raised, shaped beds with centers 1.5 m apart and thinned to 15 plants prior to vine-tip-over-stage (4 to 6 true leaves).

Testing in Michigan was done at the Michigan State University Muck Soil Research Farm at Bath, Michigan during the summers of 2007 to 2009. Weed and pest control and fertilizer application were implemented according to recommended cultural practices (Michigan State Univ. Extension Bulletin, 2004). Rows were covered with 60 cm wide plastic mulch with 1.5 m spacing between row centers. Each plot was 1.5 m long with 20 plants spaced 7.5 cm apart. One or two seeds per hole were sown and thinned to 15 plants.

The susceptible cultivar ‘Straight 8’ was planted in the borders surrounding the field, a row in the center of the field, and in three rows transferring the test germplasm plots to serve as a source of inoculum to spread the disease. These spreader rows were planted prior to the test germplasm plots, on July 6, June 30, and July 10 in 2007, 2008, and 2009, respectively. The test germplasm was planted on 9 August, 30 July, and 20 July in 2007, 2008 and 2009, respectively.

Field Ratings

Plots were rated weekly using a 0 to 9 (0=none, 1-2=trace, 3-4=slight, 5-6=moderate, 7-8=severe, 9=dead) scale that was based on percentage of symptomatic leaf area; a method developed by Jenkins and Wehner (1983) (Table 2.1). Chlorosis and necrosis were rated as the percentage of leaf area displaying each symptom. During each rating, leaves from all plants in each plot were examined and given a subjective average value of 0 to 9. Stunting was rated as reduction in plant size relative to the larger cultivars used as checks. It is a rating indicating the ability to grow large and branched. Therefore, even without disease, different genotypes would have different stunting ratings. Nevertheless, it allows us to identify those cultigens which remain large and highly branched under a disease epidemic. In 2007, stunting data was taken on the first three ratings. In 2008, stunting data was taken only on the final three ratings. In 2009, a new trait, lesion size, was added. The lesion size rating was designed to identify cultigens from another study that show hypersensitive response. It also categorized large chlorotic lesions and medium sized lesions that were chlorotic, necrotic or both. Lesion size was rated broadly into three categories: S = small necrotic flecks (possibly hypersensitive response), M = medium chlorotic and necrotic lesions, and L = large angular lesions which were mostly chlorotic. In the field, lesion size was rated numerically as 1, 5, and 9 for small, medium and large respectively. Therefore the means of lesion size data are not very useful, except in identifying cultigens with means at low and high extremes. In this case, non-parametric analysis should be used, because for means in the middle of the range it cannot be determined if they were a mix, or consistently rated in the middle, without looking at the data. We will likely incorporate this technique in the future, but for this study, our main focus was identifying cultigens that showed smallest lesion size, indicated by the smallest overall mean. Sporulation ratings were taken once at Clinton and Castle Hayne, North Carolina in 2009 only. Ratings were based on the 0 to 9 scale seen in Table 2.1.

Yield data was taken in 2008 at Clinton, North Carolina and at Clinton and Castle Hayne, North Carolina in 2009. Yield data from Castle Hayne, North Carolina in 2009 was compromised and not included in this analysis. Plots were harvested by hand and graded into marketable and cull fruit. Number of fruit and total weight were recorded for marketable and cull fruit for each plot. Plots were harvested twice.

In 2007, only overall disease was rated based on the 0 to 9 scale in Table 2.1. In 2008 and 2009, scoring of disease symptoms was performed as described above. Chlorosis and necrosis were rated in 2008 and 2009. Stunting and lesion size data were collected in 2009 along with yield data. Plots were harvested by hand and graded into marketable and cull fruit.

Inoculum Source

No artificial inoculum was used in the field plots. Plots were exposed to natural epidemics in the course of the growing season. Susceptible cultivars 'Straight 8' (2008) and 'Coolgreen' (2007 and 2009) were used in borders around the field and spreader rows spaced every ninth row to monitor and increase inoculum in the field. Epidemics were encouraged using overhead irrigation. Border rows were planted when downy mildew was confirmed to be in the area. Plots were planted when border rows showed symptoms of disease.

For the Michigan location, downy mildew infested cucumber plants were brought from commercial fields in Arenac County to directly inoculate the spreader rows. Overhead irrigation was applied after the inoculum was brought to the field to promote disease development and sporulation spread throughout the field.

Experiment Design

Eighty-six cultigens were grown under heavy downy mildew incidence in the field. The experiment was a randomized complete block design with three years (2007 to 2009), two locations, and four replications. In 2007 the locations were Clinton, North Carolina and Bath, Michigan. In 2008 the locations were Castle Hayne, North Carolina and Bath, Michigan with yield taken in North Carolina only. In 2009 the study was grown at three locations (Clinton, NC; Castle Hayne, NC; Bath, MI), with yield data taken at all locations. In the summer of 2007, four replications were grown at Clinton, North Carolina. In 2008, four replications were grown at Castle Hayne, North Carolina. Both Clinton and Castle Hayne, North Carolina had four replications in summer 2009.

Data were analyzed using the General Linear Model, Means and Correlation procedures of SAS (SAS Institute, Inc., Cary, NC). Data were analyzed combined and separately for North Carolina and Michigan. Combined data was also analyzed as seven environments (year x location combinations) (Table 2.2) to calculate correlation among disease components and mean performance for each of the cultigens tested. All correlations were calculated using the Pearson product-moment and Spearman rank methods.

Results and Discussion

Disease Resistance

Data from Michigan in 2007 was analyzed separately because only overall disease was rated. Overall disease was a combined rating of chlorosis and necrosis that did not incorporated stunting of lesion size. Over the six remaining environments in which disease components were rated, effects of all sources of variation (year, location, year x location, replication within year x location, cultigen, cultigen x year, cultigen x location, and cultigen x year x location) were significant for chlorosis and necrosis (Table 2.3). A significant effect on stunting was found for year, location, replication within year x location, cultigen, cultigen x year, and cultigen x location.

Analysis of variance was also done for separate environments, which includes the overall disease rating from Michigan in 2007 (Table 2.4). For all environments, a significant cultivar effect was found for chlorosis, necrosis and stunting. A significant cultivar effect was found in all environments for total yield, percentage marketable yield, percentage early yield, and mean fruit weight (Table 2.5).

A combined best rating was devised from F ratios and coefficients of variation for downy mildew component ratings in environments (years x locations) (Table 2.6) to compare environments using the mean of the best chlorosis and best necrosis rating for each environment (in bold) based on F-ratio and coefficient of variation. This rating was used for correlations and environment means (Tables 2.7 to 2.11).

Correlations of environments for disease were calculated using the combined best rating of components for all environments, except Michigan in 2007, for which we used the mean overall rating (Table 2.7). The data from Michigan in 2007 was not significantly correlated with any other environments. All North Carolina environments were significantly correlated at p=0.001. The Michigan environments for each year were not correlated. Correlations of environments for total and marketable yield are shown in estimated from data collected at Castle Hayne, North Carolina in 2008, and Clinton, North Carolina and Bath Michigan in 2009. All environments were significantly correlated for total and marketable yield at p=0.001 (Table 2.8). Chlorosis and necrosis were significantly correlated (0.64 and 0.55 for Pearson and Spearman correlations, respectively) at level p=0.001 (Table 2.9). This agreed with other studies conducted, which together indicate these components are likely the same trait, or controlled by the same gene(s) (unpublished data). Stunting was not correlated with either chlorosis or necrosis.

In Table 2.10 we compared cultigen performance over environments using the combined best rating described above for data that was standardized to a mean of 4.5 and standard deviation of 1.5. Data from Michigan in 2007 was a single rating of combined chlorosis and necrosis, while the rest of the data the mean of separate individual chlorosis and necrosis rating. We feel the comparison is valid because the overall rating in Michigan is really a combination of chlorosis and necrosis. The ten most resistant cultigens tested in at least one location in each year using the combined best rating were WI 2757, 'Cross Country', 'Picklet', M 21, 'MacArthur', 'Tablegreen 72', 'Pony', 'NongChen#4', 'HM 82', and 'NC-Davie'. Also of note were two experiment hybrids from Nunhems (Nun 5053 PU F1 and Nun 5054 PU F1). These were not available in 2007 but did relatively well in 2008 and 2009. A third hybrid from Nunhems (Nun 5052 PU F1) was tested in 2009 only and was susceptible to downy mildew. The least resistant cultigens tested in at least one location per year were 'Coolgreen', 'Wisconsin SMR 18', 'Straight 8', 'General Lee', 'Thunder', 'Intimidator', 'Dasher II', 'Greens leaves', 'Papillon', and 'Panther'.

In Michigan in 2007, only overall disease was rated. The ten most resistant cultigens were WI 2238, 'Wellington', 'Moxie', 'LJ 90430', 'Atlantis', 'Fancipak', 'Picklet', 'Vlaspik', 'Greensleeves', and 'Palomino'. WI 2238 was the most resistant cultigen tested in this environment, and was significantly better than all other cultigens tested. Unfortunately limited seed supply made WI 2238 unavailable for testing in 2008 and 2009. 'LJ 90430' is a little leaf type, and late to germinate. It's ranking may be misleading because part of it's resistance is likely due to disease avoidance. Data from this environment is likely not the best indicator of true resistance. M 21 is a resistant cultigen that performed relatively well in all other environments, but was not significantly different from highly susceptible 'Wisconsin SMR 18' and 'Coolgreen'.

Downy mildew chlorosis and necrosis components were rated in Bath, Michigan in 2008 and 2009. Combined data means and maximums for these are shown in Table 2.12. Cultigens are ranked by downy mildew mean, which is the mean of all chlorosis and necrosis ratings. The ten most resistant cultigens in Michigan in 2008 and 2009 using combined mean were 'Fanfare', M 21, 'Cross Country', 'Vlasset', 'Marketmore 76', 'Pony', 'MacArthur', 'Eureka', and 'Stallion'. There were 22 cultigens ranking lower, but not significantly different from 'Eureka' and 'Stallion'. The least resistant cultigens were 'Coolgreen', 'Wisconsin SMR 18', 'Intimidator', 'Straight 8', 'Talladega', 'Greensleeves', 'Sumter', Gy4, WI 1983, and 'General Lee'.

Some cultigens were not grown in each year due to limited seed supply or in the case of the Nunhems experimental hybrids, because they were not yet available. Chlorosis and necrosis means and maximums for individual years are shown in Table 2.13 and Table 2.14 for 2008 and 2009, respectively. Cultigens were ranked as described above for combined years. In 2008, the ten most resistant cultivars were 'Vlasset', M 21, WI 2757, WI 4783, 'Indy', 'Fanfare', 'Cross Country', 'Picklet', 'Colt', and Nun 5054 PU F1. In 2009, the ten most resistant cultivars were 'Fanfare', 'Calypso', 'Marketmore 76', M 21, 'MacArthur', 'Pony', 'Wainwright', 'Vlasstar', 'Stallion', and 'Powerpak'. Stunting means and maximums are also presented for data from Bath, Michigan in 2009. Stunting was not incorporated into the overall disease mean rating used to rank cultigens. Stunting was not correlated with other disease traits (Table 2.8) and there is no obvious trend in the data. This indicates that stunting is not a good measure of disease resistance in the cultigens tested. Genotypic differences may account for part of this. Cultigens would likely show variation for stunting in absence of downy mildew, especially because some cultigens tested were of determinate type.

Combined means and maximums of chlorosis, necrosis, and stunting are shown in Table 2.15. The cultigens are ranked as described above. The most resistant cultigens in North Carolina environments over 2007, 2008, and 2009 using the combined rating were 'Wautoma', M 21, 'Picklet', 'Poinsett 76', 'NC-Davie', 'Pony', 'Stonewall', 'Cates', 'HM 82', and 'Excel'. The least resistant cultigens were 'Coolgreen', 'Wisconsin SMR 18', 'Straight 8', 'Palomino', 'NC-Sunshine', 'Thunder', 'Talledega', 'Panther', 'Atlantis', and 'Papillion'.

Data is presented separately for each year (2007, 2008, and 2009) in Table 2.16, Table 2.17, and Table 2.18, respectively. This is due to addition and subtraction of some cultigens each year. In 2007, cultigens were tested in Clinton, North Carolina (Table 2.16). The most resistant cultigens in North Carolina in 2007, ranked by the combined rating as described above, were 'LJ 90430', M 21, 'NC-Davie', 'Picklet', 'Cates', 'Eureka', 'Pony', WI 4783, 'Vlasstar', and 'HM 82'. The least resistant cultigens tested in Clinton, North Carolina in 2007 were 'Coolgreen', 'National Pickling', 'Straight 8', 'Wisconsin SMR 18', 'Palomino', 'Talledega', 'NC-Sunshine', 'Ashley', 'Atlantis', and 'Thunder'.

In 2008, cultigens were tested in Castle Hayne, North Carolina (Table 2.17). The most resistant cultigens in North Carolina in 2008, ranked by the combined rating as described above, were WI 4783, WI 2757, 'NongChen#4', Nun 5054 PU F1, 'Pony', 'Stonewall', 'Cates', M 21, Nun 5053 PU F1, and 'Excel'. The least resistant cultigens tested in Castle Hayne, North Carolina in 2007 were 'Wisconsin SMR 18', 'Coolgreen', 'Thunder', 'Straight 8', 'NC-Sunshine', 'Palomino', 'General Lee', 'Talledega', 'Greensleeves', and 'Atlantis'.

In 2009, cultigens were tested at both the Clinton and Castle Hayne, North Carolina locations. Data for both locations was combined and presented in Table 2.18. Cultigens were again ranked by the combined disease rating as described above. The ten most resistant cultigens over both North Carolina locations in 2009 were 'Poinsett 76', 'Wautoma', M 21, 'Picklet', 'Fanfare', WI 2757, 'NC-Davie', 'HM 82', 'Calypso', and 'Stonewall'. The least resistant cultigens were 'Coolgreen', 'Wisconsin SMR 18', 'Straight 8', 'Palomino', 'Montebello', 'Speedway', 'Papillon', 'Panther', Nun 5052 PU F1, and 'Intimidator'.

Lesion size and sporulation ratings were taken 2009 only with means presented in Table 2.19. Cultigens were ranked using the combined disease rating described above for ease of comparison. Lesion size was rated on only a single rating date in Bath, Michigan. Almost all cultigens appear to fall into the large category for lesion size, but a few cultigens showed significantly smaller lesions for at least one location, including M 21, 'Picklet', 'Eureka', 'Cates', 'NC-Duplin', Nun 5052 PU F1, Nun 5053 PU F1, Nun 5054 PU F1, 'NongChen#4', and 'Heidan #1'. 'Heidan #1' was the only cultigen that showed significantly smaller lesion size for all locations tested. Sporulation was rated on a single rating date in Clinton and Castle Hayne, North Carolina only, in 2009. It is difficult to draw conclusions from only a single rating for sporulation, but it there does appear the most susceptible cultigens had the most sporulation. Because sporulation is difficult to rate in the field, in the future we will collect leaves in the field and quantify sporulation in the lab with a hemocytometer.

Fruit yield

Yield data was collected from Castle Hayne, North Carolina in 2008, and Clinton and Castle Hayne, North Carolina in 2009, as well as Bath, Michigan in 2009. Data from Castle Hayne, North Carolina in 2009 was compromised and not included in this analysis. Data were from two harvests at each location and are shown in Table 2.20. Cultigens are ranked by mean total yield from the environments tested. The ten highest yielding cultigens were WI 1983, Nun 5054 PU F1, Nun 5052 PU F1, Nun 5053 PU F1, 'Cates', 'Starex', 'Pony', 'Vlasspear', 'Classy', and 'Fancipak'. Seed availability limited testing of WI 1983 to 2008 only, but it was the second highest yielding cultigen that year. Interestingly, the three experimental Nunhems hybrids all yielded well, with a high percentage of marketable fruit. In Bath, Michigan in 2009, these cultigens outperformed all other cultigens by at least twice the LSD. Nun 5052 was generally ranked as susceptible in disease tests, indicating this hybrid has high tolerance to downy mildew. Tolerance is the ability to yield under disease pressure. In general, the highest yielding cultigens were also the most resistant. The highest yield achieved was the cultivar 'Cates' in Clinton, North Carolina in 2009, with 25.6 Mg/ha.

Conclusions

Prior to 2004, cultivars in use were highly resistant to downy mildew in the United States, and no fungicide was needed to grow a successful crop. None of the cultigens tested in this study showed this high level of high resistance, although differences in cultigens still exist. Until new resistance becomes available, growers would likely benefit by growing those cultigens that we have shown to perform well for disease and yield. Growing cultigens with high tolerance to downy mildew may allow fewer fungicide applications and in turn reduce cost to growers, but this connection needs to be studied further. Growers should use this information, along with extension information, to make the best decisions possible when choosing cultivars to grow each year. It is important to select cultivars with the agronomic traits required by the final consumer, i.e. length and diameter for pickle processing, so this information is necessary as well. Selecting a cultivar with best agronomic traits for a growers area, with the best resistance and tolerance available should give growers an advantage. Growers should always stay up to date with the latest extension information and new cultivars available through seed companies, as improved cultivars are release each year. In this study, unreleased cultivars from Nunhem's performed very well. It is likely that other seed companies have improved cultivars in the pipeline as well, that were not tested in this study. An informed grower has a much greater chance of success during unfavorable conditions.

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Table 2.1. Subjective rating scale for field assessment of foliar resistance to downy mildew in cucumber for chlorosis and necrosis.

Subjective Rating	Percent of leaf area affected by chlorosis or necrosis	Description of symptoms
0	0	No symptoms
1	1-3	Trace
2	3-6	Trace
3	6-12	Slight
4	12-25	Slight
5	25-50	Moderate
6	50-75	Moderate
7	75-87	Severe
8	87-99	Severe
9	100	Plant dead

Table 2.2. Seven environments (locations by year) used in evaluation of selected cultivars of *C. sativus* for resistance to downy mildew.

Location	Year
Bath, MI	2007
Clinton, NC	2007
Bath, MI	2008
Castle Hayne, NC	2008
Bath, MI	2009
Clinton, NC	2009
Castle Hayne, NC	2009

Table 2.3. Analysis of variance for downy mildew component ratings in North Carolina and Michigan from 2007-2009, excluding Michigan 2007[z].

Source of variation	df	Downy Mildew Disease Component (Mean Squares) Chlorosis[y] Mean	Necrosis[x] Mean	Stunting[w] Mean
Year	2	132.87 ***	130.41 ***	
Location	2	84.61 ***	307.86 ***	
Year*Location	1	44.47 ***	73.44 ***	
Rep(Year*Location)	18	4.21 ***	5.37 ***	
Cultigen	84	11.76 ***	3.95 ***	
Cultigen*Year	134	0.83 ***	0.85 ***	
Cultigen*Location	157	0.90 ***	1.19 ***	
Cultigen*Year*Loc.	61	1.06 ***	1.25 ***	
Error	1268	0.37 ***	0.47 ***	
Year	2			125.55 ***
Location	2			27.20 ***
Year*Location	0			-
Rep(Year*Location)	15			8.16 ***
Cultigen	84			6.88 ***
Cultigen*Year	134			1.77 ***
Cultigen*Location	149			1.75 ***
Cultigen*Year*Loc.	0			-
Error	1064			0.85 ***

z Data are from four replications excluding data from Bath, MI in 2007.
y Mean of chlorosis ratings for all years and replications.
x Mean of necrosis ratings for all years and replications.
w Mean of stunting ratings from all years in NC and 2009 in MI.
*,**,*** Significant at 0.05, 0.01, and 0.001 respectively

Table 2.4. Analysis of variance for downy mildew component ratings in environments (years by locations from from 2007 to 2009[z].

Source of variation	df	Downy Mildew Disease Component (Mean Squares) Chlorosis[y] Mean	Necrosis[x] Mean	Stunting[w] Mean	MI 2007 Disease
2007 Bath, Michigan					
Replication	3	-	-	-	0.58
Cultivar	71	-	-	-	1.93***
Error	195	-	-	-	0.99***
2007 Clinton, North Carolina					
Replication	3	0.40	6.12***	2.67***	-
Cultivar	72	3.02***	1.79***	2.39***	-
Error	216	0.18***	0.18***	0.43***	-
2008 Bath, Michigan					
Replication	3	0.81	10.27***	-	-
Cultivar	69	1.57***	1.95***	-	-
Error	204	0.43***	0.74***	-	-
2008 Castle Hayne, North Carolina					
Replication	3	4.93***	4.78***	4.72**	-
Cultivar	69	3.96***	1.87***	3.76***	-
Error	206	0.41***	0.57***	0.95***	-
2009 Bath, Michigan					
Replication	3	0.84	5.13***	2.61***	-
Cultivar	72	4.54***	1.16***	3.16***	-
Error	180	0.46***	0.40***	0.55***	-
2009 Clinton, North Carolina					
Replication	3	11.27***	3.67***	9.39***	-
Cultivar	72	2.92***	1.97***	3.65***	-
Error	216	0.48***	0.54***	1.28***	-
2009 Castle Hayne, North Carolina					
Replication	3	7.02***	2.24***	21.43***	-
Cultivar	77	3.23***	1.59***	3.87***	-
Error	231	0.27***	0.40***	0.95***	-

z Data are from four replications.
y Mean of all ratings for chlorosis with replications.
x Mean of all ratings for necrosis with replications.
w Mean of all ratings for stunting with replications.
*,**,*** Significant at 0.05, 0.01, and 0.001 respectively

Table 2.5. Analysis of variance for yield traits in environments (year by location)[z].

Source of variation	df	Downy Mildew Yield Component (Mean Squares) Total Mg/ha	% Marketable[y]	% early[x]	kg/ fruit[w]
2008 Castle Hayne, North Carolina					
Replication	3	62.53 ***	2005.95 ***	1752.91 ***	0.0071 ***
Cultivar	78	55.60 ***	1087.89 ***	1513.40 ***	0.0029 ***
Error	234	8.83 ***	493.93 ***	460.11 ***	0.0011 ***
2009 Bath, Michigan					
Replication	3	2.31	428.66	83.08	0.0009
Cultivar	78	39.77 ***	1928.55 ***	1167.82 ***	0.0022 ***
Error	234	4.07 ***	780.09 ***	420.60 ***	0.0011 ***
2009 Clinton, North Carolina					
Replication	3	879.36 ***	887.69	1202.78 *	0.0321 ***
Cultivar	78	140.71 ***	1292.58 ***	2416.60 ***	0.0054 ***
Error	234	41.37 ***	454.39 ***	461.87 ***	0.0028 ***

z Data are from four replications with two harvests each.
y Percent marketable yield measured as percent non-culled fruit by weight.
x Percent early yield measured as percent of total yield in harvest 1 of 2.
w Mean fruit weight in kg.
*,**,*** Significant at 0.05, 0.01, and 0.001 respectively

Table 2.6. F-Ratio and Coefficient of variation for downy mildew component ratings in environments (years x locations) tested in North Carolina and Michigan from 2007 to 2009[z].

			Chlorosis		Necrosis		Stunting	
Year	Location	Rating	F	CV	F	CV	F	CV
All	All	Avg	12.50	13.11	7.72	14.33	5.42	23.52
2007	Bath, MI[y]		-	-	-	-	-	-
	Clinton, NC	1	6.91	35.27	2.83	28.46	3.09	0.52
		2	6.20	21.28	5.48	9.89	3.35	26.47
		3	5.12	23.92	5.78	18.27	4.22	27.67
		4	5.67	22.86	4.06	25.44	4.80	53.60
		5	6.00	19.12	8.22	18.67	-	-
		Avg	16.12	11.87	11.02	9.29	5.59	22.61
2008	Bath, MI	1	-	-	-	-	-	-
		2	-	-	-	-	-	-
		3	3.10	23.07	3.47	33.14	-	-
		4	2.29	28.83	2.21	37.55	-	-
		5	3.35	21.03	2.25	27.20	-	-
		Avg	3.56	15.89	3.09	20.66	-	-
	Castle Hayne, NC	1	3.67	23.83	2.59	13.64	-	-
		2	7.59	25.08	2.27	25.56	-	-
		3	4.62	24.73	3.12	21.31	2.74	30.01
		4	3.97	23.70	2.09	28.05	3.26	36.90
		5	3.36	14.75	6.11	18.31	2.87	24.03
		Avg	9.71	11.92	3.52	12.81	3.98	23.27
2009	Bath, MI	1	3.01	35.58	1.33	38.90	3.28	56.19
		2	6.22	26.28	1.95	22.49	3.29	26.72
		3	3.81	20.37	2.75	25.66	3.97	20.11
		4	3.74	22.54	3.49	23.23	5.00	16.30
		Avg	9.54	14.54	3.23	15.98	5.77	16.60
	Clinton, NC	1	5.05	36.52	2.73	38.75	2.33	41.87
		2	5.13	16.72	2.36	17.99	2.65	40.06
		3	6.93	17.25	3.07	24.65	3.18	43.02
		4	3.50	22.42	3.08	25.77	2.31	31.08
		5	3.30	19.39	1.96	16.53	2.82	30.83
		Avg	6.68	13.89	3.77	13.33	3.02	27.47
	Castle Hayne, NC	1	2.55	40.12	1.78	42.43	4.37	33.40
		2	7.91	19.90	2.03	26.63	2.82	32.57
		3	4.23	14.22	3.34	25.96	3.82	37.51
		4	6.13	21.74	2.92	33.17	4.00	32.78
		5	7.61	15.92	4.42	14.80	4.21	24.30
		Avg	12.67	10.32	4.02	14.00	4.77	24.52

z Data is from four replications.
y No component data from Michigan in 2007.

Table 2.7. Pearson product-moment correlation coefficients (above diagonal) and Spearman's rank correlation coefficients (below diagonal) for environments (Year x Location) of best downy mildew ratings in North Carolina and Michigan from 2007 to 2009[z].

	Environment (Year x Location)						
	2007-CI[y]	2007-MI[x]	2008-CH[w]	2008-MI[v]	2009-CI[u]	2009-CH[t]	2009-MI[s]
2007-CI		-0.07	0.42***	0.21	0.51***	0.68***	0.07
2007-MI	-0.12		0.14	0.17	0.07	-0.18	0.18
2008-CH	0.38**	0.16		0.63***	0.59***	0.47***	0.33**
2008-MI	0.13	0.09	0.52***		0.37**	0.28*	0.21
2009-CI	0.47***	0.05	0.53***	0.31**		0.55***	0.16
2009-CH	0.69***	-0.13	0.41***	0.22	0.55***		0.15
2009-MI	0.01	0.24	0.44***	0.24	0.21	0.16	

z Data are from four replications.
y Data is combined best ratings from Clinton, NC, in 2007.
x Data is mean disease rating from Bath, MI, in 2007.
w Data is combined best ratings from Castle Hayne, NC, in 2008.
v Data is combined best ratings from Bath, MI, in 2008.
u Data is combined best ratings from Clinton, NC, in 2009.
t Data is combined best ratings from Castle Hayne, NC, in 2009.
s Data is combined best ratings from Bath, MI, in 2009.
*,**,*** Significant at 0.05, 0.01, and 0.001 respectively

Table 2.8. Pearson product-moment correlation coefficients (above diagonal) and Spearman's rank correlation coefficients (below diagonal) for yield in environments (Year x Location)^{z}.

	C.Hayne^{y} NC 2008	Clinton^{x} NC 2009	Bath^{v} MI 2009
Total Mg/ha			
Castle Hayne, NC 2008		0.66***	0.64***
Clinton, NC 2009	0.69***		0.47***
Bath, MI 2009	0.61***	0.64***	
Marketable Mg/ha			
Castle Hayne, NC 2008		0.65***	0.69***
Clinton, NC 2009	0.69***		0.48***
Bath, MI 2009	0.66***	0.59***	

z Data are from two harvests and four replications for each environment.
y Data is from Castle Hayne, NC, in 2008.
x Data Clinton, NC, in 2009.
w Data is from Bath, MI, in 2009.
*,**,*** Significant at 0.05, 0.01, and 0.001 respectively

Table 2.9. Pearson product-moment correlation coefficients (above diagonal) and Spearman's rank correlation coefficients (below diagonal) of disease traits in North Carolina and Michigan from 2007 to 2009[z].

Trait	Chlorosis[y]	Necrosis[x]	Stunting[w]
Chlorosis		0.64***	0.04
Necrosis	0.54***		0.04
Stunting	-0.04	-0.11	

z Data are from four replications in all environments. Bath, Michigan, 2007 not included.
y Data is mean of all chlorosis ratings.
x Data is mean of all necrosis ratings.
w Data is mean of all stunting ratings.
*, **,**Significant at 0.05, 0.01 and 0.001, respectively.

Table 2.10. Downy mildew resistance of cultivars tested in Bath, MI, and Clinton and Castle Hayne, NC from 2007-2009[z].

Cultivar or line	DM Best	2007 Clinton[y]	2007 Bath[x]	2008 C.Hayne[w]	2008 Bath[v]	2009 Clinton[u]	2009 C.Hayne[t]	2009 Bath[s]
TMG-1	.	.	.	.	.	.	.	.
LJ 90430	3.0	1.5	2.7	.	.	.	.	.
WI 2757	3.1	3.8	3.6	1.9	3.2	3.4	2.3	.
WI 4783	3.1	2.7	4.2	2.2	2.5	.	.	.
NC-Danbury	3.2	.	.	3.7	3.8	.	.	.
WI 2238 (R,S)	3.3	4.2	-0.4	.	.	.	.	.
Picklet	3.4	2.7	3.2	3.3	3.1	2.9	3.3	3.5
M 21	3.6	2.7	4.9	2.8	1.8	3.1	4.7	4.1
MacArthur	3.6	3.8	3.8	3.7	4.6	3.5	2.3	1.9
Pony	3.6	3.3	4.1	3.2	3.1	4.0	3.3	2.3
NongChen#4	3.6	2.4	5.2	3.0	3.8	4.2	2.8	4.1
Poinsett 76	3.7	3.3	5.6	2.6	4.2	2.5	3.0	.
H-19	3.8	.	.	.	.	2.8	4.3	3.3
Fanfare	3.8	3.8	5.5	4.3	3.1	3.4	1.7	.
Cross Country	3.9	4.2	4.8	3.2	3.1	3.4	4.1	.
Invasion	3.9	.	.	.	.	4.6	2.1	4.1
Heidan#1 (I,R)	3.9	2.4	6.8	.	.	4.0	0.5	5.3
Eureka	3.9	2.7	5.6	4.3	3.7	2.9	3.1	4.3
Nun 5054 PU F1	3.9	.	.	3.0	4.0	5.4	4.4	3.1
Fancipak	3.9	2.9	3.0	5.0	4.8	3.2	3.4	4.6
Spunky	3.9	4.5	3.8	3.6	3.3	4.8	3.1	4.1
NC-Davie	3.9	3.3	3.6	3.6	4.9	3.1	4.3	3.8
Mopick	4.0	.	.	.	.	3.5	3.6	4.1
Wautoma	4.0	2.9	5.9	.	.	2.5	2.5	4.8
Impact	4.1	3.6	4.3	3.3	4.4	3.8	4.3	4.3
Wellington	4.1	4.8	2.3	4.0	3.7	3.5	5.2	5.8
Feisty	4.1	4.5	4.1	4.7	3.7	3.8	3.6	4.5
Moxie	4.1	5.2	2.4	4.6	4.8	3.7	3.4	4.6
Stonewall	4.2	3.5	5.6	2.6	5.1	3.4	3.3	6.3
Nun 5053 PU F1	4.2	.	.	3.3	4.6	6.2	4.3	2.8
Vlasstar	4.3	4.5	4.7	4.1	4.2	4.0	4.6	2.8
Slice	4.3	3.2	5.4	4.0	6.4	3.7	3.1	4.3
Homegreen #2	4.3	2.6	5.4	5.0	3.8	4.0	4.3	4.8
Tablegreen 72	4.3	3.2	.	5.8	5.7	4.2	4.1	.
HM 82	4.3	6.0	4.1	3.7	4.6	2.3	5.6	3.6
WI 1983	4.3	.	.	4.4	5.8	.	.	.
Europick	4.4	.	.	.	.	3.8	4.3	4.8

Table 2.10 Continued

Indy	4.4	3.2	5.2	4.3	3.5	5.4	4.1	5.0
Lafayette	4.4	4.6	4.1	3.6	4.9	4.8	4.4	4.1
Excel	4.4	5.1	3.8	3.3	3.7	3.5	5.6	6.3
Navigator	4.4	4.8	3.8	3.7	4.4	4.9	5.4	3.8
HM 81	4.4	4.4	4.3	4.3	5.7	2.5	4.9	5.8
Vlaspik	4.5	4.9	3.3	3.7	4.8	4.6	5.7	3.8
Powerpak	4.5	4.4	3.8	4.0	5.1	5.2	4.7	4.1
Vlasset	4.5	5.1	4.4	4.3	1.8	5.4	5.1	5.1
Pershing	4.5	4.6	5.4	4.4	4.9	4.3	3.4	4.3
Starex	4.5	5.2	4.0	4.4	4.0	5.1	5.2	2.8
Sassy	4.5	6.3	5.0	4.0	3.3	4.5	4.1	4.1
Journey	4.5	4.6	4.1	3.9	4.0	5.4	5.2	4.1
Calypso	4.6	4.9	3.6	6.1	5.3	3.1	3.9	3.8
Wainwright	4.6	4.9	4.0	.	.	4.2	4.9	1.9
Cates	4.6	4.1	5.0	4.1	4.9	4.3	5.7	4.1
Sumter	4.6	4.1	5.7	5.0	4.2	4.0	4.4	5.1
Gy 4	4.6	4.5	4.4	4.7	4.9	4.8	4.4	4.8
Classy	4.6	4.9	4.6	4.6	4.6	4.8	3.9	5.3
Arabian	4.6	5.7	4.7	4.0	4.2	4.6	4.6	5.0
Colt	4.7	5.4	4.3	4.7	4.0	5.1	4.9	3.8
Expedition	4.7	5.4	4.7	4.3	3.8	4.3	6.2	4.1
Ashley	4.7	4.4	4.4	5.5	4.9	4.6	4.7	4.3
Diamante	4.7	4.4	5.6	4.1	5.8	4.8	4.1	4.8
Marketmore 76	4.7	4.2	5.9	5.3	4.2	4.6	3.8	.
Vlasspear	4.7	5.8	3.8	4.4	4.6	4.5	5.9	4.3
Jackson(3540)	4.8	5.2	4.6	4.6	4.4	4.8	6.0	3.5
Talladega	4.8	4.8	3.8	6.5	6.2	4.9	3.3	4.8
NC-Duplin	4.8	5.1	4.8	4.4	4.9	4.0	5.6	6.1
Panther	4.9	3.8	4.7	5.8	4.8	5.5	5.2	5.5
Greensleaves	4.9	4.1	3.4	6.8	5.3	5.5	4.9	5.3
Atlantis	5.0	6.7	2.8	5.5	4.0	5.1	5.7	5.5
Dasher II	5.0	4.2	4.8	5.4	5.5	5.7	5.1	5.5
NC-Stratford	5.0	5.5	4.9	4.8	4.4	5.7	5.6	4.5
Stallion	5.0	7.0	5.0	5.0	4.6	4.6	5.2	5.0
General Lee	5.0	3.8	5.5	6.5	5.7	5.5	4.4	4.6
M 41	5.1	4.4	5.5	.	.	.	.	.
Intimidator	5.1	4.1	4.7	6.0	6.2	5.5	5.2	5.8
Speedway	5.2	.	.	.	.	6.0	4.1	6.0
Thunder	5.2	4.5	4.2	6.2	5.5	6.0	6.0	5.0
Ballerina	5.2	.	.	.	.	5.1	6.2	4.8
NC-Sunshine	5.3	6.9	5.9	5.7	3.7	4.9	6.0	4.8
Papillon	5.3	6.0	4.6	5.1	4.6	6.3	7.0	4.8

Table 2.10 Continued

Montebello	5.4	.	.	.	.	6.3	4.9	5.5
Nun 5052	5.5	.	.	.	.	6.2	6.4	4.3
Palomino	5.7	7.9	3.4	6.2	4.6	6.8	7.0	4.8
Straight 8	5.9	7.0	5.9	6.8	6.8	5.8	5.9	4.6
Wis.SMR 18	6.2	5.8	5.4	7.6	7.7	6.8	7.3	4.8
Coolgreen	6.3	6.0	5.7	7.3	6.9	7.4	6.0	.
NationlPcklng	6.4	7.8	4.2	.	.	.	.	.
LSD (5%)	0.6	0.5	1.7	1.0	0.6	0.8	0.7	0.7

z Data is from four replications for each year, location. Data was standardized to a mean of 4.5 and standard deviation of 1.5.
y Data is combined best ratings from Clinton, NC, in 2007.
x Data is mean disease rating from Bath, MI, in 2007.
w Data is combined best ratings from Castle Hayne, NC, in 2008.
v Data is combined best ratings from Bath, MI, in 2008.
u Data is combined best ratings from Clinton, NC, in 2009.
t Data is combined best ratings from Castle Hayne, NC, in 2009.
s Data is combined best ratings from Bath, MI, in 2009.

Table 2.11. Mean overall disease ratings from Bath, Michigan in 2007[z].

Cultivar	Source	Disease
WI 2238 (R,S)	USDA-Wis	3.3
Wellington	Seminis	5.3
Moxie	Harris Moran	5.4
LJ 90430	USDA,LaJolla	5.6
Atlantis	Bejo Seeds	5.7
Fancipak	Seminis	5.9
Picklet	Seminis	6.0
Vlaspik	Seminis	6.1
Greensleaves	Harris Moran	6.2
Palomino	Seminis	6.2
WI 2757	USDA-Wis	6.3
Calypso	NC StateUniv	6.3
NC-Davie	ZeraimGedera	6.3
Excel	Seminis	6.4
Navigator	Seminis	6.4
Powerpak	Seminis	6.4
Vlasspear	Seminis	6.4
Spunky	Harris Moran	6.4
Talladega	Seminis	6.4
MacArthur	Nunhems	6.5
Starex	Baker	6.6
Wainwright	Nunhems	6.6
HM 82	Harris Moran	6.6
Journey	Seminis	6.6
Pony	Seminis	6.6
Feisty	Harris Moran	6.7
Lafayette	Nunhems	6.7
Thunder	Seminis	6.7
WI 4783	USDA-Wis	6.7
NationlPcklng	NSSL	6.8
Colt	Seminis	6.8
HM 81	Harris Moran	6.8
Impact	Western	6.8
Gy 4	NC StateUniv	6.9
Vlasset	Seminis	6.9
Ashley	Clemson Univ	6.9
Jackson(3540)	Nunhems	7.0
Classy	Harris Moran	7.0
Papillon	Seminis	7.1
Intimidator	Seminis	7.1
Panther	Nunhems	7.1
Arabian	Seminis	7.1
Expedition	Seminis	7.1
Vlasstar	Seminis	7.1
Cross Country	Harris Moran	7.2
Dasher II	PetoSeed	7.2

Table 2.11 Continued

NC-Duplin	NCState Univ	7.2
M 21	NC StateUniv	7.3
NC-Stratford	NC StateUniv	7.3
Cates	Nunhems	7.3
Sassy	Harris Moran	7.3
Stallion	Seminis	7.3
Indy	Seminis	7.5
NongChen#4	PR China	7.5
Homegreen #2	USDA-Wis	7.6
Slice	Clemson Univ	7.6
Wis.SMR 18	WisconsinAES	7.6
Pershing	Nunhems	7.7
M 41	NC StateUniv	7.7
Fanfare	Seminis	7.7
General Lee	Harris Moran	7.7
Diamante	Harris Moran	7.8
Eureka	Seminis	7.8
Poinsett 76	Cornell Univ	7.8
Stonewall	Harris Moran	7.8
Coolgreen	Asgrow Seed	7.8
Sumter	Clemson Univ	7.9
Marketmore 76	Cornell Univ	8.0
NC-Sunshine	NC StateUniv	8.0
Straight 8	NSSL	8.0
Wautoma	Wis-USDA	8.0
Heidan#1 (I,R)	PR China	8.7
LSD (5%)		1.4

z Data are means of four replications.

Table 2.12. Downy Mildew resistance of cultivars tested in Bath, Michigan, 2008 to 2009[z].

Cultivar or line	Source	DM Mean[y]	Downy Mildew Disease Components: Chlorosis Mean	Chlorosis Max	Necrosis Mean	Necrosis Max
Fanfare	Seminis	2.9	3.3	4.4	2.5	3.4
M 21	NC StateUniv	3.2	2.5	3.4	3.7	6.1
Cross Country	Harris Moran	3.3	3.3	4.5	3.3	5.3
Vlasset	Seminis	3.4	3.1	4.5	3.8	5.3
Picklet	Seminis	3.6	3.5	4.9	3.8	5.1
Marketmore 76	Cornell Univ	3.7	4.0	5.3	3.4	4.6
Pony	Seminis	3.7	3.2	3.8	4.3	5.5
MacArthur	Nunhems	3.7	3.7	5.0	3.8	4.8
Eureka	Seminis	3.8	3.8	5.6	3.7	5.5
Stallion	Seminis	3.8	3.5	5.0	4.0	5.5
Journey	Seminis	3.8	3.8	5.3	3.8	4.8
Starex	Baker	3.8	3.8	5.1	3.9	5.6
Poinsett 76	Cornell Univ	3.8	4.1	6.0	3.6	5.5
Impact	Western	3.8	4.1	5.8	3.6	5.0
Expedition	Seminis	3.9	3.7	5.3	4.0	5.4
Homegreen #2	USDA-Wis	3.9	4.0	5.5	3.7	5.6
Calypso	NC StateUniv	3.9	3.8	5.6	3.9	5.3
Colt	Seminis	3.9	3.5	5.4	4.2	5.7
Feisty	Harris Moran	3.9	3.6	5.0	4.3	5.3
Nun 5054 PU F1	Nunhems	4.0	4.2	5.9	3.8	5.4
Cates	Nunhems	4.0	3.6	5.1	4.4	5.4
Indy	Seminis	4.0	5.0	6.5	3.0	4.5
HM 82	Harris Moran	4.0	3.8	5.5	4.3	5.9
Arabian	Seminis	4.0	3.8	5.3	4.3	5.8
Sassy	Harris Moran	4.1	3.7	4.6	4.4	5.9
NC-Davie	ZeraimGedera	4.1	4.3	6.0	3.7	5.1
NC-Duplin	NCState Univ	4.1	4.2	5.6	3.8	6.0
Jackson(3540)	Nunhems	4.1	3.8	5.7	4.4	5.5
Lafayette	Nunhems	4.1	4.0	5.6	4.2	5.5
Vlasstar	Seminis	4.1	3.8	4.9	4.4	6.4
Classy	Harris Moran	4.1	4.2	5.6	4.0	5.5
Vlaspik	Seminis	4.1	3.7	5.3	4.5	5.7
Spunky	Harris Moran	4.2	4.2	5.6	4.1	5.5
Powerpak	Seminis	4.2	3.8	5.1	4.5	5.6
NC-Stratford	NC StateUniv	4.2	5.0	6.1	3.3	4.0
Excel	Seminis	4.2	4.2	5.8	4.1	5.9
Moxie	Harris Moran	4.2	4.0	5.5	4.5	6.3
Nun 5053 PU F1	Nunhems	4.2	4.4	6.1	4.0	4.8
Wellington	Seminis	4.2	3.9	5.3	4.7	5.9
NC-Sunshine	NC StateUniv	4.2	5.1	6.4	3.4	4.5
Atlantis	Bejo Seeds	4.3	5.3	6.8	3.2	4.5
Navigator	Seminis	4.3	4.0	5.9	4.5	6.0
Vlasspear	Seminis	4.3	4.0	5.8	4.6	6.0
Palomino	Seminis	4.3	5.0	6.3	3.5	5.4

Table 2.12 Continued

NongChen#4	PR China	4.3	4.7	6.4	4.0	5.5
Fancipak	Seminis	4.3	4.2	5.6	4.5	5.8
Ballerina	Nunhems	4.3	5.7	6.8	2.9	3.5
Tablegreen 72	Cornell Univ	4.4	4.4	6.5	4.3	6.0
Pershing	Nunhems	4.4	4.3	5.9	4.5	5.8
Panther	Nunhems	4.5	5.1	6.9	3.7	5.3
Papillon	Seminis	4.5	4.9	6.3	4.2	5.5
Thunder	Seminis	4.5	5.3	6.9	3.8	4.9
NC-Danbury	NCState Univ	4.6	4.1	6.3	5.1	8.0
Ashley	Clemson Univ	4.7	5.8	6.9	3.6	5.3
Diamante	Harris Moran	4.7	4.3	6.3	5.1	6.4
HM 81	Harris Moran	4.7	5.0	7.1	4.3	5.8
Stonewall	Harris Moran	4.7	4.5	6.1	5.0	6.6
Dasher II	PetoSeed	4.7	5.5	7.1	3.8	4.9
Slice	Clemson Univ	4.7	4.8	6.8	4.7	6.0
General Lee	Harris Moran	4.8	5.4	6.8	4.2	5.4
WI 1983	USDA-Wis	4.8	4.9	6.5	4.7	6.3
Gy 4	NC StateUniv	4.8	4.8	6.6	4.7	6.8
Sumter	Clemson Univ	4.8	4.9	6.5	4.8	6.9
Greensleaves	Harris Moran	4.9	5.8	6.9	3.9	5.3
Talladega	Seminis	5.0	5.8	7.8	4.3	5.9
Straight 8	NSSL	5.0	5.6	7.6	4.3	5.8
Intimidator	Seminis	5.0	5.6	7.3	4.5	5.9
Wis.SMR 18	WisconsinAES	5.2	6.3	7.8	4.1	5.8
Coolgreen	Asgrow Seed	5.7	5.9	7.7	5.4	7.0
LSD (5%)		0.6	0.7	0.9	0.8	1.2

z Data are from four replications each in Bath, Michigan in 2008 and 2009.
y DM Mean is mean of all chlorosis and necrosis ratings.

Table 2.13. Downy mildew resistance components for cultivars tested in Bath, Michigan in 2008[z].

Cultivar or line	Source	DM Mean[y]	Downy Mildew Disease Components: Chlorosis Mean	Chlorosis Max	Necrosis Mean	Necrosis Max
Vlasset	Seminis	2.6	2.7	3.8	2.5	4.3
M 21	NC StateUniv	2.9	2.3	2.5	3.5	6.3
WI 2757	USDA-Wis	3.0	3.7	5.3	2.3	3.3
WI 4783	USDA-Wis	3.1	2.8	4.7	3.3	5.7
Indy	Seminis	3.2	3.4	5.5	2.9	4.3
Fanfare	Seminis	3.3	3.6	5.8	3.0	4.8
Cross Country	Harris Moran	3.3	3.3	4.5	3.3	5.3
Picklet	Seminis	3.5	3.6	4.8	3.3	4.5
Colt	Seminis	3.5	3.8	5.5	3.3	5.0
Nun 5054 PU F1	Nunhems	3.6	3.9	5.8	3.3	4.8
Homegreen #2	USDA-Wis	3.6	3.7	5.8	3.5	5.8
Eureka	Seminis	3.7	3.8	5.5	3.5	5.3
Journey	Seminis	3.7	3.5	4.8	3.8	4.8
Impact	Western	3.7	4.0	5.8	3.4	5.0
Feisty	Harris Moran	3.7	3.6	4.8	3.8	5.0
Pony	Seminis	3.7	3.8	4.5	3.7	5.5
Atlantis	Bejo Seeds	3.8	4.3	6.0	3.3	4.5
Palomino	Seminis	3.8	4.2	6.3	3.3	5.3
Starex	Baker	3.8	3.5	5.0	4.1	6.5
NC-Sunshine	NC StateUniv	3.8	4.2	5.8	3.4	4.8
Poinsett 76	Cornell Univ	3.8	4.1	6.0	3.6	5.5
Wellington	Seminis	3.8	3.5	4.5	4.2	5.8
NC-Duplin	NCState Univ	3.8	3.8	5.5	3.9	6.0
Stallion	Seminis	3.8	3.7	5.3	4.0	5.5
Arabian	Seminis	3.9	3.6	4.8	4.2	6.0
Expedition	Seminis	3.9	3.5	4.8	4.3	5.8
Classy	Harris Moran	3.9	3.8	5.0	3.9	5.5
NC-Davie	ZeraimGedera	3.9	3.7	5.0	4.1	5.3
MacArthur	Nunhems	3.9	4.2	6.0	3.7	4.5
Excel	Seminis	3.9	3.8	5.0	4.1	6.0
Nun 5053 PU F1	Nunhems	3.9	3.8	5.3	4.0	4.5
HM 82	Harris Moran	4.0	3.8	5.8	4.2	6.3
Cates	Nunhems	4.0	3.8	5.3	4.3	5.3
Sassy	Harris Moran	4.1	4.0	5.3	4.2	5.8
Vlasspear	Seminis	4.1	4.0	5.8	4.2	5.8
Spunky	Harris Moran	4.1	3.9	5.5	4.3	5.8
Marketmore 76	Cornell Univ	4.1	4.4	6.5	3.8	6.3
Vlaspik	Seminis	4.1	3.9	5.5	4.3	6.0
Ashley	Clemson Univ	4.1	4.7	6.8	3.6	5.0
NC-Stratford	NC StateUniv	4.1	4.7	5.5	3.6	4.3
Jackson(3540)	Nunhems	4.2	3.9	5.8	4.4	5.8
NongChen#4	PR China	4.3	4.0	6.0	4.5	6.3
Lafayette	Nunhems	4.3	4.2	5.5	4.4	6.3
Thunder	Seminis	4.3	4.3	6.0	4.3	5.5

Table 2.13 Continued

Papillon	Seminis	4.4	4.1	5.8	4.7	6.3
Navigator	Seminis	4.4	4.3	6.3	4.4	6.3
Tablegreen 72	Cornell Univ	4.4	4.4	6.5	4.3	6.0
Panther	Nunhems	4.4	4.4	6.5	4.4	6.3
Vlasstar	Seminis	4.4	4.3	5.8	4.6	7.0
Stonewall	Harris Moran	4.5	4.2	6.0	4.8	6.3
Powerpak	Seminis	4.5	3.9	5.0	5.1	6.3
Moxie	Harris Moran	4.6	4.4	6.3	4.8	6.5
NC-Danbury	NCState Univ	4.6	4.1	6.3	5.1	8.0
Sumter	Clemson Univ	4.6	4.4	6.5	4.8	7.5
Fancipak	Seminis	4.6	4.5	5.8	4.8	6.3
Calypso	NC StateUniv	4.7	4.7	6.3	4.7	6.5
Pershing	Nunhems	4.7	4.8	7.0	4.5	5.8
WI 1983	USDA-Wis	4.8	4.9	6.5	4.7	6.3
General Lee	Harris Moran	4.8	4.8	6.3	4.8	6.3
Intimidator	Seminis	4.8	4.8	7.0	4.9	6.0
HM 81	Harris Moran	4.9	4.8	7.5	4.9	6.3
Diamante	Harris Moran	4.9	4.6	6.5	5.2	6.5
Straight 8	NSSL	4.9	5.1	7.5	4.8	6.5
Greensleaves	Harris Moran	4.9	5.3	6.5	4.6	5.8
Dasher II	PetoSeed	5.0	5.3	6.8	4.8	6.3
Talladega	Seminis	5.1	5.1	7.5	5.1	6.8
Slice	Clemson Univ	5.2	4.8	7.0	5.5	6.5
Gy 4	NC StateUniv	5.3	5.0	6.8	5.5	8.3
Wis.SMR 18	WisconsinAES	5.5	5.6	7.8	5.3	7.3
Coolgreen	Asgrow Seed	5.7	5.9	7.7	5.4	7.0
LSD (5%)		0.9	0.9	1.5	1.2	1.8

z Data are from four replications each in Bath, Michigan in 2008.
y DM Mean is mean of all chlorosis and necrosis ratings.

Table 2.14. Downy mildew resistance components for cultivars tested in Bath, Michigan in 2009[z].

Cultivar or line	Source	DM Mean[y]	Downy Mildew Disease Components					
			Chlorosis		Necrosis		Stunting	
			Mean	Max	Mean	Max	Mean	Max
Fanfare	Seminis	2.5	3.0	3.0	2.0	2.0	4.0	4.0
Calypso	NC StateUniv	3.1	3.0	5.0	3.2	4.0	6.3	7.0
Marketmore 76	Cornell Univ	3.3	3.5	4.0	3.0	3.0	3.5	6.0
M 21	NC StateUniv	3.5	2.8	4.3	3.9	6.0	6.2	7.7
MacArthur	Nunhems	3.6	3.3	4.0	3.9	5.0	5.4	6.5
Pony	Seminis	3.7	2.6	3.0	4.9	5.5	5.5	7.0
Wainwright	Nunhems	3.8	4.0	5.3	3.5	4.0	4.8	6.3
Vlasstar	Seminis	3.8	3.3	4.0	4.3	5.8	4.4	6.0
Stallion	Seminis	3.8	3.4	4.8	4.0	5.5	5.3	6.5
Powerpak	Seminis	3.8	3.7	5.3	3.9	5.0	4.4	6.0
Picklet	Seminis	3.8	3.3	5.0	4.2	5.7	4.3	5.3
Starex	Baker	3.8	4.2	5.3	3.7	4.8	4.9	6.5
Moxie	Harris Moran	3.8	3.6	4.8	4.2	6.0	3.8	5.5
Expedition	Seminis	3.8	3.8	5.8	3.8	5.0	5.2	6.8
Eureka	Seminis	3.8	3.8	5.8	3.9	5.8	5.5	7.0
Lafayette	Nunhems	3.9	3.8	5.8	3.9	4.8	4.3	6.0
H-19	UnivArkansas	3.9	3.5	5.0	4.3	6.0	6.4	8.0
Cates	Nunhems	3.9	3.4	5.0	4.5	5.5	4.8	6.0
Europick	United Gen.	3.9	3.6	5.5	4.3	5.8	5.2	6.5
Journey	Seminis	4.0	4.1	5.8	3.8	4.8	3.9	5.5
Impact	Western	4.0	4.3	5.8	3.7	5.0	3.8	5.5
Jackson(3540)	Nunhems	4.0	3.8	5.7	4.3	5.3	4.9	6.7
Fancipak	Seminis	4.0	4.0	5.5	4.3	5.3	3.7	4.8
Sassy	Harris Moran	4.0	3.4	4.0	4.6	6.0	4.8	6.5
HM 82	Harris Moran	4.0	3.8	5.3	4.5	5.5	5.6	6.5
Vlaspik	Seminis	4.1	3.4	5.0	4.8	5.3	5.2	6.3
Navigator	Seminis	4.1	3.8	5.5	4.5	5.8	4.8	6.5
Feisty	Harris Moran	4.1	3.7	5.3	4.7	5.7	4.5	6.3
Wautoma	Wis-USDA	4.1	5.3	7.0	2.8	4.0	6.5	7.0
Homegreen #2	USDA-Wis	4.2	4.3	5.3	4.0	5.5	5.0	6.8
Pershing	Nunhems	4.2	3.8	4.8	4.6	5.8	6.1	7.0
Arabian	Seminis	4.2	4.1	5.8	4.4	5.5	4.9	6.5
Spunky	Harris Moran	4.2	4.5	5.8	3.9	5.3	4.1	6.3
Colt	Seminis	4.3	3.3	5.3	5.1	6.3	5.8	7.3
Mopick	United Gen.	4.3	3.8	5.3	4.7	5.8	3.6	5.0
NC-Davie	ZeraimGedera	4.3	5.0	7.0	3.4	5.0	3.8	6.0
NC-Stratford	NC StateUniv	4.3	5.4	6.7	3.1	3.7	5.3	6.0
Slice	Clemson Univ	4.3	4.7	6.5	4.0	5.5	4.4	5.8
Vlasset	Seminis	4.3	3.6	5.3	5.1	6.3	5.3	6.3
NC-Duplin	NCState Univ	4.3	4.7	5.7	3.7	6.0	6.5	7.7
Invasion	Western	4.3	4.8	6.0	4.0	5.8	3.3	5.0
Classy	Harris Moran	4.3	4.5	6.3	4.1	5.5	4.4	6.0
Nun 5054 PU F1	Nunhems	4.3	4.5	6.0	4.3	6.0	2.4	3.0
Ballerina	Nunhems	4.3	5.7	6.8	2.9	3.5	4.1	6.3

Table 2.14 Continued

Dasher II	PetoSeed	4.3	5.8	7.5	2.8	3.5	3.5	5.5
Gy 4	NC StateUniv	4.4	4.7	6.5	3.9	5.3	4.8	6.5
NongChen#4	PR China	4.4	5.3	6.8	3.5	4.8	3.2	4.5
Diamante	Harris Moran	4.4	4.0	6.0	5.0	6.3	4.6	6.3
Vlasspear	Seminis	4.4	4.0	5.8	5.0	6.3	4.6	6.3
Excel	Seminis	4.5	4.7	6.5	4.2	5.8	5.0	6.5
HM 81	Harris Moran	4.5	5.3	6.8	3.7	5.3	4.7	6.3
Panther	Nunhems	4.5	5.8	7.3	3.1	4.3	4.2	5.7
Nun 5053 PU F1	Nunhems	4.5	5.1	7.0	3.9	5.0	2.4	3.5
Wellington	Seminis	4.6	4.3	6.0	5.2	6.0	5.5	7.0
Papillon	Seminis	4.6	5.6	6.8	3.8	4.8	5.1	6.8
NC-Sunshine	NC StateUniv	4.7	6.0	7.0	3.5	4.3	5.9	7.3
Montebello	United Gen.	4.7	6.0	7.5	3.5	4.8	3.4	4.8
General Lee	Harris Moran	4.7	6.1	7.3	3.5	4.5	3.2	4.8
Atlantis	Bejo Seeds	4.8	6.3	7.5	3.2	4.5	4.4	6.0
Palomino	Seminis	4.8	5.9	6.3	3.6	5.5	5.4	7.0
Thunder	Seminis	4.8	6.3	7.8	3.4	4.3	3.6	5.8
Greensleaves	Harris Moran	4.8	6.4	7.3	3.3	4.8	3.5	5.8
Indy	Seminis	4.8	6.6	7.5	3.1	4.8	3.9	6.0
Stonewall	Harris Moran	4.9	4.8	6.3	5.2	7.0	3.8	5.5
Nun 5052 PU F1	Nunhems	4.9	6.0	7.5	3.8	5.3	2.2	3.0
Speedway	Seminis	4.9	5.8	7.0	4.2	5.3	3.9	5.5
Talladega	Seminis	4.9	6.4	8.0	3.5	5.0	3.7	4.8
Wis.SMR 18	WisconsinAES	5.0	7.1	7.8	2.9	4.3	4.9	6.0
Sumter	Clemson Univ	5.1	5.4	6.5	4.8	6.3	4.5	5.8
Straight 8	NSSL	5.1	6.2	7.8	3.9	5.0	5.6	7.8
Ashley	Clemson Univ	5.2	6.9	7.0	3.7	5.5	3.5	5.0
Intimidator	Seminis	5.2	6.4	7.5	4.1	5.8	3.9	5.8
Heidan#1 (I,R)	PR China	5.4	6.8	7.8	4.1	5.5	3.1	4.8
LSD (5%)		0.6	1.0	1.2	1.1	1.4	1.0	1.3

z Data are from four replications each in Bath, Michigan in 2009.
y DM Mean is mean of all chlorosis and necrosis ratings.

Table 2.15. Downy mildew resistance components for cultivars tested in Clinton and Castle Hayne, North Carolina, 2007 to 2009[z].

Cultivar or line	Source	DM Mean[y]	Downy Mildew Disease Components: Chlorosis Mean	Chlorosis Max	Necrosis Mean	Necrosis Max	Stunting Mean	Stunting Max
Wautoma	Wis-USDA	3.8	3.7	5.3	3.8	5.9	4.5	5.4
M 21	NC StateUniv	3.9	3.7	5.9	3.9	6.6	4.7	5.8
Picklet	Seminis	4.1	3.9	5.6	4.3	6.4	4.2	5.3
Poinsett 76	Cornell Univ	4.1	4.0	5.8	4.2	6.5	4.5	5.5
NC-Davie	ZeraimGedera	4.2	4.0	5.8	4.3	6.7	3.7	4.8
Pony	Seminis	4.2	3.8	5.6	4.5	6.6	3.5	4.7
Stonewall	Harris Moran	4.2	3.6	5.4	4.9	7.2	3.1	4.4
Cates	Nunhems	4.3	4.0	5.4	4.5	6.9	3.2	4.6
HM 82	Harris Moran	4.3	4.1	6.2	4.4	6.8	4.4	5.6
Excel	Seminis	4.3	4.1	6.0	4.4	6.9	4.1	5.4
Mopick	United Gen.	4.4	4.1	5.8	4.3	6.8	3.6	4.8
Cross Country	Harris Moran	4.4	3.9	5.6	4.9	7.3	3.8	4.9
Wainwright	Nunhems	4.4	4.0	5.5	4.5	7.2	3.2	4.8
Eureka	Seminis	4.4	4.2	5.7	4.7	6.7	4.1	5.4
Fanfare	Seminis	4.4	4.0	6.1	4.9	6.9	5.5	6.7
Slice	Clemson Univ	4.5	3.8	5.8	5.1	7.3	2.7	3.9
MacArthur	Nunhems	4.5	4.1	5.9	5.0	6.8	4.2	5.6
Vlasstar	Seminis	4.5	4.1	5.9	5.0	7.2	3.4	4.5
NongChen#4	PR China	4.6	4.9	6.7	4.4	6.9	3.5	4.6
Fancipak	Seminis	4.6	4.4	5.9	4.9	7.0	2.5	3.8
Diamante	Harris Moran	4.6	4.1	5.8	5.1	7.1	2.7	3.9
HM 81	Harris Moran	4.6	4.6	6.1	4.6	6.7	3.2	4.3
Impact	Western	4.6	4.2	5.8	5.0	7.2	3.3	4.3
Lafayette	Nunhems	4.6	4.3	5.8	5.0	7.2	3.6	4.9
Classy	Harris Moran	4.7	4.5	6.3	4.8	6.9	3.1	4.6
Powerpak	Seminis	4.7	3.9	5.9	5.4	7.4	3.1	4.6
Wellington	Seminis	4.7	4.2	6.1	5.1	7.4	4.0	5.4
Gy 4	NC StateUniv	4.7	4.5	6.1	4.8	7.0	3.8	5.1
Spunky	Harris Moran	4.7	4.4	6.1	5.1	7.3	2.7	4.1
Feisty	Harris Moran	4.7	4.1	5.6	5.3	7.3	3.3	4.6
Pershing	Nunhems	4.7	4.2	5.8	5.2	7.3	3.7	5.2
Journey	Seminis	4.7	4.3	5.8	5.0	7.1	3.7	5.1
Calypso	NC StateUniv	4.7	4.8	5.9	4.7	6.8	3.4	5.0
Nun 5054 PU F1	Nunhems	4.8	4.6	6.2	4.9	7.0	3.8	5.5
NC-Duplin	NCState Univ	4.8	4.3	6.3	5.2	7.1	3.8	5.0
Arabian	Seminis	4.8	4.4	6.2	5.2	7.1	4.3	5.6
Vlaspik	Seminis	4.8	4.5	6.3	5.1	7.2	3.4	4.6
Homegreen #2	USDA-Wis	4.8	4.9	6.6	4.8	6.9	5.4	6.5
Moxie	Harris Moran	4.8	4.4	6.2	5.2	7.3	3.2	4.4
Navigator	Seminis	4.9	4.5	6.4	5.1	7.1	3.5	5.1
Colt	Seminis	4.9	4.5	5.9	5.3	7.4	3.6	4.9
Expedition	Seminis	4.9	4.7	6.4	5.1	7.1	3.9	5.6
Starex	Baker	4.9	4.7	6.3	5.1	7.2	2.5	3.8

Table 2.15 Continued

Sassy	Harris Moran	5.0	4.3	6.2	5.5	7.3	3.7	5.6
Jackson(3540)	Nunhems	5.0	4.6	6.6	5.5	7.4	4.3	5.9
Nun 5053 PU F1	Nunhems	5.0	4.8	6.3	5.1	7.3	4.3	5.9
Stallion	Seminis	5.0	4.5	6.6	5.4	7.8	4.1	5.4
Vlasspear	Seminis	5.0	4.8	6.6	5.1	7.3	3.8	5.3
Vlasset	Seminis	5.1	4.7	6.3	5.3	7.2	4.1	5.4
Sumter	Clemson Univ	5.1	4.8	6.4	5.3	7.3	4.2	5.6
Tablegreen 72	Cornell Univ	5.1	5.3	6.7	5.0	7.1	5.2	6.5
Indy	Seminis	5.2	5.3	6.8	5.1	6.9	3.1	4.4
Marketmore 76	Cornell Univ	5.3	5.5	7.3	5.0	6.8	4.4	5.4
NC-Stratford	NC StateUniv	5.4	5.5	7.1	5.2	7.4	4.1	5.6
Dasher II	PetoSeed	5.5	5.6	6.9	5.4	7.4	2.8	4.5
Greensleaves	Harris Moran	5.5	5.8	7.2	5.3	7.3	3.1	4.2
Ashley	Clemson Univ	5.5	5.9	6.9	5.2	7.3	3.9	5.1
General Lee	Harris Moran	5.6	5.7	6.8	5.5	7.4	2.8	4.1
Intimidator	Seminis	5.6	5.7	7.1	5.5	7.2	3.0	4.4
Papillon	Seminis	5.7	5.9	7.4	5.3	7.3	3.3	4.9
Atlantis	Bejo Seeds	5.7	5.9	7.3	5.4	7.5	4.1	5.7
Panther	Nunhems	5.7	5.8	7.1	5.6	7.3	3.2	4.4
Talladega	Seminis	5.7	5.6	7.2	5.7	7.4	3.7	5.3
Thunder	Seminis	5.8	5.9	7.1	5.6	7.6	2.9	4.4
NC-Sunshine	NC StateUniv	5.8	6.0	7.2	5.5	7.7	4.7	5.9
Palomino	Seminis	6.2	6.2	7.7	6.2	7.9	3.9	5.2
Straight 8	NSSL	6.6	6.6	7.8	6.5	8.1	5.1	6.7
Wis.SMR 18	WisconsinAES	6.8	7.0	8.1	6.6	8.1	4.3	5.9
Coolgreen	Asgrow Seed	6.8	7.0	8.3	6.6	8.1	6.1	7.5
LSD (5%)		0.4	0.4	0.5	0.5	0.5	0.7	0.8

z Data are from four replications each in Clinton, NC in 2009.
y DM Mean is mean of all chlorosis and necrosis ratings.

Table 2.16. Downy mildew resistance components for cultivars tested in Clinton, North Carolina in 2007[z].

Cultivar or line	Source	DM Mean[y]	Downy Mildew Disease Components: Chlorosis Mean	Chlorosis Max	Necrosis Mean	Necrosis Max	Stunting Mean	Stunting Max
LJ 90430	USDA,LaJolla	2.3	1.7	2.5	3.0	5.3	3.8	6.0
M 21	NC StateUniv	2.8	2.4	3.8	3.2	5.3	3.1	4.0
NC-Davie	ZeraimGedera	3.1	2.6	4.0	3.7	6.0	1.9	2.8
Picklet	Seminis	3.2	2.7	4.0	3.8	5.5	2.4	3.3
Cates	Nunhems	3.2	2.8	4.0	3.5	5.3	2.5	4.0
Eureka	Seminis	3.3	2.8	4.3	4.0	5.8	2.3	4.0
Pony	Seminis	3.3	2.7	4.3	4.1	6.0	2.0	3.0
WI 4783	USDA-Wis	3.4	2.7	4.3	4.2	6.5	4.1	5.5
Vlasstar	Seminis	3.5	2.7	4.8	4.4	5.5	2.4	3.3
HM 82	Harris Moran	3.6	3.0	5.8	4.0	6.0	2.8	3.3
Gy 4	NC StateUniv	3.6	2.9	4.5	4.3	6.5	2.8	3.8
M 41	NC StateUniv	3.6	3.6	5.3	3.5	5.5	3.4	4.8
Fancipak	Seminis	3.6	3.1	4.5	4.3	6.0	2.4	3.8
NC-Duplin	NCState Univ	3.6	3.0	5.0	4.2	5.5	2.0	2.8
Excel	Seminis	3.6	3.0	4.8	4.3	5.8	2.5	3.8
Stonewall	Harris Moran	3.7	2.8	4.3	4.7	6.3	2.8	4.5
WI 2238 (R,S)	USDA-Wis	3.7	3.5	5.0	3.9	5.5	3.7	4.8
Wautoma	Wis-USDA	3.7	3.1	4.5	4.3	6.5	3.4	4.3
Poinsett 76	Cornell Univ	3.7	3.3	4.8	4.3	6.3	2.7	4.0
Wainwright	Nunhems	3.7	3.2	4.8	4.1	6.0	1.9	3.0
Spunky	Harris Moran	3.7	3.1	5.3	4.5	7.0	2.1	3.0
Navigator	Seminis	3.7	3.3	5.0	4.1	5.8	2.2	2.8
Wellington	Seminis	3.7	3.0	4.5	4.6	6.3	2.4	3.5
Cross Country	Harris Moran	3.7	3.2	4.5	4.4	7.0	2.4	3.8
Classy	Harris Moran	3.8	3.4	5.0	4.2	5.8	2.3	3.5
Powerpak	Seminis	3.8	2.8	4.3	5.0	6.8	2.6	3.5
Homegreen #2	USDA-Wis	3.8	3.2	5.0	4.7	7.3	4.3	5.0
Journey	Seminis	3.8	3.3	4.5	4.5	5.8	2.8	4.0
Jackson(3540)	Nunhems	3.8	3.1	5.8	4.9	6.8	3.8	4.8
Impact	Western	3.8	3.1	4.5	4.8	6.8	3.1	4.3
Lafayette	Nunhems	3.8	2.9	4.8	5.0	6.8	2.9	3.8
HM 81	Harris Moran	3.8	3.5	4.8	4.2	6.0	2.2	3.0
MacArthur	Nunhems	3.8	3.2	4.8	4.5	6.5	2.5	3.5
Feisty	Harris Moran	3.9	3.1	4.8	4.7	6.8	2.6	4.0
Pershing	Nunhems	3.9	2.9	4.3	4.9	6.5	3.4	4.5
Expedition	Seminis	3.9	3.3	5.3	4.4	6.0	2.8	4.5
Colt	Seminis	3.9	3.0	4.5	4.7	6.5	2.8	3.5
Vlaspik	Seminis	3.9	3.2	5.0	4.6	6.0	1.9	2.8
NongChen#4	PR China	3.9	3.8	5.0	4.3	6.3	3.4	4.8
Starex	Baker	3.9	3.6	5.5	4.2	6.0	1.5	2.5
Slice	Clemson Univ	3.9	3.4	5.3	4.6	7.0	2.5	4.0
Diamante	Harris Moran	3.9	3.3	5.0	4.8	6.0	2.0	3.3
WI 2757	USDA-Wis	4.0	3.5	4.8	4.6	6.3	4.6	5.8
Arabian	Seminis	4.0	3.4	5.0	4.7	6.3	2.2	3.0

Table 2.16 Continued

Heidan#1 (I,R)	PR China	4.1	4.3	6.3	4.0	6.0	4.9	6.3
Sumter	Clemson Univ	4.1	3.7	5.3	4.7	6.5	3.3	5.0
Moxie	Harris Moran	4.1	3.4	5.3	5.1	6.8	2.5	3.5
Vlasspear	Seminis	4.2	3.7	5.5	4.6	6.3	2.6	4.0
Fanfare	Seminis	4.2	3.5	4.8	5.1	6.8	4.1	5.5
Stallion	Seminis	4.2	3.4	6.0	5.0	7.5	2.9	3.8
NC-Stratford	NC StateUniv	4.2	4.0	6.0	4.5	6.3	2.6	3.8
Indy	Seminis	4.2	3.9	5.8	4.8	6.8	3.1	4.8
Calypso	NC StateUniv	4.3	3.7	4.8	5.0	6.3	2.4	4.3
Vlasset	Seminis	4.3	3.8	5.3	4.8	6.5	3.2	4.3
Sassy	Harris Moran	4.4	3.5	6.0	5.2	6.8	2.8	4.3
Panther	Nunhems	4.5	4.2	5.8	4.9	6.8	2.7	3.8
Tablegreen 72	Cornell Univ	4.5	4.1	5.5	4.9	7.0	3.9	5.0
Papillon	Seminis	4.5	4.4	6.5	4.5	5.8	1.6	2.8
General Lee	Harris Moran	4.5	4.3	5.8	5.0	6.8	2.9	4.0
Dasher II	PetoSeed	4.6	4.5	5.8	5.0	6.8	2.4	3.8
Marketmore 76	Cornell Univ	4.6	4.3	6.0	5.1	7.0	3.3	4.5
Intimidator	Seminis	4.6	4.6	6.3	4.8	6.5	2.3	3.5
Greensleaves	Harris Moran	4.6	4.3	6.0	5.2	7.3	3.2	4.5
Thunder	Seminis	4.7	4.7	5.8	5.0	6.8	2.1	3.3
Atlantis	Bejo Seeds	4.8	4.4	6.5	5.3	6.8	3.1	4.5
Ashley	Clemson Univ	4.8	4.7	5.5	5.1	7.0	3.2	4.8
NC-Sunshine	NC StateUniv	5.0	4.7	6.3	5.3	7.0	3.3	4.5
Talladega	Seminis	5.1	4.7	6.5	5.7	7.8	3.3	5.0
Palomino	Seminis	5.2	4.9	7.5	5.5	7.5	2.7	3.3
Wis.SMR 18	WisconsinAES	5.9	5.6	7.3	6.4	8.0	4.1	5.8
Straight 8	NSSL	6.3	6.1	7.8	6.6	7.8	5.2	6.0
NationlPcklng	NSSL	6.3	6.0	7.5	6.7	7.8	3.8	5.5
Coolgreen	Asgrow Seed	6.5	6.5	7.5	6.7	8.0	4.4	6.0
LSD (5%)		0.5	0.6	1.2	0.8	1.0	0.9	1.3

z Data are from four replications each in Clinton, NC in 2007 and 2009, and Castle Hayne, NC in 2008 and 2009.
y DM Mean is mean of all chlorosis and necrosis ratings.

Table 2.17. Downy mildew resistance components for cultivars tested in Castle Hayne, North in 2008[z].

Cultivar or line	Source	DM Mean[y]	Downy Mildew Disease Components: Chlorosis Mean	Chlorosis Max	Necrosis Mean	Necrosis Max	Stunting Mean	Stunting Max
WI 4783	USDA-Wis	3.5	3.1	5.5	4.4	6.5	5.2	6.5
WI 2757	USDA-Wis	4.1	4.0	5.0	4.4	6.3	7.2	8.0
NongChen#4	PR China	4.3	4.7	6.5	4.3	6.8	5.5	6.3
Nun 5054 PU F1	Nunhems	4.4	4.0	6.3	5.4	8.0	3.1	4.0
Pony	Seminis	4.6	4.1	6.3	5.6	7.8	4.3	5.0
Stonewall	Harris Moran	4.7	4.1	6.3	5.7	8.3	3.8	4.3
Cates	Nunhems	4.7	3.9	6.3	5.6	7.5	2.9	3.8
M 21	NC StateUniv	4.8	4.2	7.0	5.6	8.0	5.0	6.0
Nun 5053 PU F1	Nunhems	4.8	4.1	6.0	5.7	8.3	4.6	5.0
Excel	Seminis	4.9	5.0	7.8	5.0	7.5	4.3	5.3
Picklet	Seminis	4.9	4.8	6.8	5.5	7.5	4.4	5.5
Poinsett 76	Cornell Univ	5.0	4.8	7.0	5.7	7.8	5.0	5.5
Spunky	Harris Moran	5.1	4.8	6.3	5.7	8.3	3.0	4.0
Sassy	Harris Moran	5.1	4.3	6.3	6.2	7.5	4.1	5.0
Cross Country	Harris Moran	5.1	4.4	6.8	6.3	8.5	3.8	4.8
HM 82	Harris Moran	5.1	4.7	6.8	5.9	7.8	5.0	6.3
NC-Davie	ZeraimGedera	5.2	4.8	7.0	5.9	8.0	4.8	5.0
Lafayette	Nunhems	5.2	5.0	6.5	5.9	8.3	3.4	4.3
Impact	Western	5.2	5.0	6.8	5.8	7.8	3.4	4.0
Vlasset	Seminis	5.3	4.9	6.5	5.9	7.5	5.0	6.0
Slice	Clemson Univ	5.3	4.4	6.5	6.6	8.3	3.6	4.3
Journey	Seminis	5.3	4.9	6.5	6.1	8.3	4.5	5.3
Indy	Seminis	5.4	5.7	7.3	5.3	7.0	4.3	5.3
Powerpak	Seminis	5.4	4.3	6.5	6.8	8.3	3.8	4.8
Vlasstar	Seminis	5.4	5.2	7.3	6.0	8.3	4.5	5.3
Vlaspik	Seminis	5.4	5.1	7.3	6.1	8.0	4.0	4.8
Fanfare	Seminis	5.4	4.9	7.0	6.3	8.0	5.5	6.5
Navigator	Seminis	5.4	5.1	7.3	5.8	7.5	4.3	5.3
Diamante	Harris Moran	5.4	4.6	6.8	6.6	8.5	2.8	3.5
Classy	Harris Moran	5.5	5.4	7.3	6.0	8.3	3.6	4.5
HM 81	Harris Moran	5.5	5.5	7.0	5.7	7.0	3.5	4.5
MacArthur	Nunhems	5.6	4.7	7.5	6.6	8.0	4.1	5.5
Expedition	Seminis	5.6	5.3	6.8	6.1	7.5	4.0	5.3
WI 1983	USDA-Wis	5.6	6.1	7.8	5.5	7.8	3.7	4.5
Eureka	Seminis	5.6	5.0	7.0	6.5	8.3	3.8	4.5
Vlasspear	Seminis	5.7	5.4	7.3	6.3	8.3	3.8	4.8
NC-Danbury	NCState Univ	5.7	5.2	7.0	6.3	8.0	5.3	6.3
Wellington	Seminis	5.7	4.8	7.0	6.8	8.3	4.4	5.5
Feisty	Harris Moran	5.7	4.8	6.5	6.9	8.8	3.3	3.8
Pershing	Nunhems	5.7	5.1	7.0	6.6	8.3	4.5	5.8
Arabian	Seminis	5.7	4.8	7.0	6.9	8.3	5.9	6.8
Gy 4	NC StateUniv	5.7	5.7	7.3	6.0	7.8	3.8	4.5
Fancipak	Seminis	5.7	5.5	7.0	6.3	8.3	2.7	3.0
Jackson(3540)	Nunhems	5.8	5.1	7.5	6.7	8.0	4.4	5.3

Table 2.17 Continued

NC-Duplin	NCState Univ	5.8	5.0	7.0	6.9	8.3	4.1	5.0
Starex	Baker	5.8	5.7	7.3	6.3	8.5	2.6	3.3
Moxie	Harris Moran	5.9	5.3	7.0	6.8	8.5	3.7	4.5
Sumter	Clemson Univ	5.9	5.3	7.0	6.8	8.3	4.7	5.5
Colt	Seminis	6.0	5.3	7.3	6.9	8.5	4.1	5.0
Tablegreen 72	Cornell Univ	6.0	5.7	7.0	6.7	8.5	4.7	5.8
Marketmore 76	Cornell Univ	6.0	6.4	7.8	5.8	7.3	4.0	5.0
Calypso	NC StateUniv	6.1	6.2	7.5	6.5	8.5	3.4	4.3
Intimidator	Seminis	6.1	6.6	7.5	5.9	7.3	4.1	4.8
Homegreen #2	USDA-Wis	6.1	6.4	7.5	6.1	7.8	6.0	7.0
Ashley	Clemson Univ	6.2	6.7	7.5	6.1	8.3	4.0	4.8
Papillon	Seminis	6.2	6.8	7.8	6.0	8.0	4.0	4.8
NC-Stratford	NC StateUniv	6.2	6.5	8.0	6.3	8.3	4.2	5.3
Panther	Nunhems	6.3	6.7	8.0	6.3	8.0	3.4	4.5
Dasher II	PetoSeed	6.3	6.7	7.8	6.5	8.8	3.1	4.3
Stallion	Seminis	6.4	5.9	7.8	7.0	8.5	4.0	5.0
Atlantis	Bejo Seeds	6.4	6.5	7.8	6.7	8.3	4.4	6.0
Greensleaves	Harris Moran	6.6	7.1	7.8	6.4	8.3	2.8	3.5
Talladega	Seminis	6.6	6.6	7.8	6.9	8.3	3.0	3.8
General Lee	Harris Moran	6.7	7.0	7.8	6.7	8.5	2.9	3.8
Palomino	Seminis	6.7	6.8	7.8	7.0	8.5	4.3	5.5
NC-Sunshine	NC StateUniv	6.8	7.2	8.0	6.8	8.8	5.2	6.3
Straight 8	NSSL	6.9	6.8	7.8	7.1	8.8	6.6	7.8
Thunder	Seminis	6.9	7.1	8.3	7.0	8.8	3.6	5.0
Coolgreen	Asgrow Seed	7.2	7.0	8.5	7.4	8.8	7.5	8.3
Wis.SMR 18	WisconsinAES	7.8	8.0	8.8	7.8	8.8	4.6	5.8
LSD (5%)		0.8	0.9	1.0	1.1	1.1	1.4	1.6

z Data are from four replications each in Clinton, NC in 2007 and 2009, and Castle Hayne, NC in 2008 and 2009.
y DM Mean is mean of all chlorosis and necrosis ratings.

Table 2.18. Downy mildew resistance components for cultivars tested in Clinton and Castle Hayne, North Carolina in 2009^{z}.

Cultivar or line	Source	DM Mean^{y}	Downy Mildew Disease Components: Chlorosis Mean	Chlorosis Max	Necrosis Mean	Necrosis Max	Stunting Mean	Stunting Max
Poinsett 76	Cornell Univ	3.9	4.0	5.6	3.5	6.0	5.2	6.3
Wautoma	Wis-USDA	3.9	4.0	5.6	3.6	5.6	5.1	6.0
M 21	NC StateUniv	3.9	4.2	6.5	3.4	6.5	5.3	6.6
Picklet	Seminis	4.1	4.0	5.9	3.9	6.4	5.0	6.3
Fanfare	Seminis	4.1	3.8	6.3	4.0	6.5	6.1	7.4
WI 2757	USDA-Wis	4.1	4.5	6.1	3.5	6.1	5.4	6.3
NC-Davie	ZeraimGedera	4.2	4.3	6.0	3.8	6.4	4.2	5.6
HM 82	Harris Moran	4.3	4.3	6.1	3.9	6.8	4.9	6.5
Calypso	NC StateUniv	4.3	4.6	5.8	3.8	6.1	4.0	5.8
Stonewall	Harris Moran	4.3	3.9	5.6	4.5	7.1	3.0	4.4
Cross Country	Harris Moran	4.4	4.0	5.5	4.4	6.8	4.6	5.6
MacArthur	Nunhems	4.4	4.2	5.6	4.4	6.3	5.0	6.6
Mopick	United Gen.	4.4	4.1	5.8	4.3	6.8	3.6	4.8
Eureka	Seminis	4.4	4.4	5.8	4.1	6.4	5.1	6.5
Pony	Seminis	4.4	4.2	6.0	4.2	6.3	3.9	5.4
Slice	Clemson Univ	4.4	3.8	5.8	4.7	7.0	2.4	3.8
Excel	Seminis	4.4	4.3	5.8	4.2	7.1	4.8	6.4
Invasion	Western	4.5	4.2	6.0	4.5	6.5	3.5	5.0
Diamante	Harris Moran	4.6	4.2	5.6	4.6	6.9	3.1	4.5
Fancipak	Seminis	4.6	4.5	6.1	4.5	6.9	2.4	4.3
HM 81	Harris Moran	4.6	4.7	6.4	4.3	6.9	3.7	4.9
Wellington	Seminis	4.6	4.5	6.4	4.4	7.5	4.6	6.4
Vlasstar	Seminis	4.6	4.2	5.8	4.8	7.5	3.4	4.8
Feisty	Harris Moran	4.7	4.2	5.5	4.8	6.9	3.6	5.4
Pershing	Nunhems	4.7	4.3	5.9	4.7	7.1	3.5	5.3
Moxie	Harris Moran	4.7	4.5	6.3	4.5	6.9	3.4	4.8
Cates	Nunhems	4.7	4.6	5.8	4.4	7.5	3.6	5.3
Classy	Harris Moran	4.7	4.7	6.5	4.5	6.9	3.4	5.3
Gy 4	NC StateUniv	4.7	4.6	6.3	4.5	6.9	4.4	6.1
Homegreen #2	USDA-Wis	4.7	5.0	6.9	4.2	6.4	5.7	7.0
Impact	Western	4.7	4.4	6.0	4.7	7.1	3.3	4.5
Heidan#1 (I,R)	PR China	4.7	5.6	7.8	3.9	6.4	4.1	5.5
Arabian	Seminis	4.8	4.6	6.4	4.6	6.9	4.5	6.3
Lafayette	Nunhems	4.8	4.7	5.9	4.5	6.9	4.2	5.9
Powerpak	Seminis	4.8	4.3	6.4	4.9	7.4	3.0	5.1
Wainwright	Nunhems	4.8	4.4	5.9	4.8	7.8	3.9	5.8
Stallion	Seminis	4.8	4.4	6.4	4.8	7.5	4.7	6.4
NC-Duplin	NCState Univ	4.8	4.5	6.5	4.8	7.4	4.6	6.1
Europick	United Gen.	4.8	4.9	6.4	4.6	6.6	3.5	4.9
Journey	Seminis	4.9	4.6	6.1	4.8	7.3	3.7	5.5
Nun 5054 PU F1	Nunhems	4.9	4.9	6.1	4.6	6.5	4.1	6.3
Colt	Seminis	5.0	4.8	6.0	4.8	7.4	3.8	5.6
Spunky	Harris Moran	5.0	4.8	6.4	5.1	6.9	2.9	4.8

Table 2.18 Continued

Vlaspik	Seminis	5.0	4.8	6.5	4.8	7.4	3.9	5.5
Starex	Baker	5.0	4.8	6.3	4.9	7.1	3.0	4.6
H-19	UnivArkansas	5.1	5.1	6.5	4.6	7.5	3.2	5.1
Tablegreen 72	Cornell Univ	5.1	5.7	7.1	4.2	6.5	6.1	7.6
NongChen#4	PR China	5.1	5.6	7.6	4.5	7.3	2.5	3.6
Nun 5053 PU F1	Nunhems	5.1	5.2	6.5	4.9	6.8	4.2	6.4
Sumter	Clemson Univ	5.2	5.1	6.6	5.0	7.3	4.5	6.0
Expedition	Seminis	5.2	5.1	6.8	4.9	7.5	4.4	6.3
Vlasspear	Seminis	5.2	5.1	6.9	4.8	7.3	4.4	6.1
Sassy	Harris Moran	5.2	4.7	6.3	5.3	7.4	4.0	6.6
Marketmore 76	Cornell Univ	5.2	5.7	7.6	4.6	6.4	5.2	6.0
Jackson(3540)	Nunhems	5.2	5.0	6.6	5.2	7.4	4.5	6.8
Navigator	Seminis	5.3	4.8	6.8	5.3	7.5	3.8	6.3
Vlasset	Seminis	5.3	5.2	6.6	5.2	7.4	4.2	5.6
Ballerina	Nunhems	5.3	5.7	7.4	4.7	7.4	4.4	6.3
Greensleaves	Harris Moran	5.5	6.0	7.5	4.7	6.8	3.2	4.4
Dasher II	PetoSeed	5.5	5.6	7.0	5.1	7.1	2.9	5.0
NC-Stratford	NC StateUniv	5.5	5.7	7.1	5.0	7.5	4.9	6.6
Talladega	Seminis	5.5	5.6	7.3	5.1	6.9	4.3	6.1
General Lee	Harris Moran	5.5	5.7	6.9	5.1	7.1	2.6	4.3
Ashley	Clemson Univ	5.6	6.1	7.4	4.8	6.9	4.2	5.4
Indy	Seminis	5.7	5.8	7.1	5.3	6.9	2.6	3.8
NC-Sunshine	NC StateUniv	5.7	6.2	7.3	5.0	7.5	5.1	6.5
Atlantis	Bejo Seeds	5.7	6.3	7.5	4.9	7.5	4.5	6.1
Thunder	Seminis	5.8	5.9	7.1	5.3	7.5	3.0	4.8
Intimidator	Seminis	5.9	5.9	7.4	5.6	7.5	2.8	4.8
Nun 5052 PU F1	Nunhems	5.9	6.2	7.6	5.4	7.5	4.7	6.8
Panther	Nunhems	6.0	6.2	7.3	5.6	7.3	3.3	4.6
Papillon	Seminis	6.0	6.3	7.6	5.3	7.6	3.8	6.0
Speedway	Seminis	6.0	6.2	7.3	5.7	7.4	4.1	5.3
Montebello	United Gen.	6.1	6.1	7.3	5.9	8.0	3.1	4.6
Palomino	Seminis	6.5	6.7	7.8	6.1	7.9	4.3	6.0
Straight 8	NSSL	6.6	6.8	7.9	6.1	7.9	4.3	6.5
Wis.SMR 18	WisconsinAES	6.8	7.2	8.1	6.0	7.9	4.2	6.0
Coolgreen	Asgrow Seed	6.8	7.2	8.6	6.1	7.8	6.3	7.9
LSD (5%)		0.6	0.6	0.8	0.7	0.7	1.1	1.2

z Data are from four replications each in Clinton, NC in 2007 and 2009, and Castle Hayne, NC in 2008 and 2009.
y DM Mean is mean of all chlorosis and necrosis ratings.

Table 2.19. Lesion size and sporulation component ratings of downy mildew on cultivars tested in Bath, Michigan, and Clinton and Castle Hayne, North Carolina in 2009^{z}.

Cultivar or line	Source	DM Mean^{y}	Lesion Size: Bath MI^{x}	Lesion Size: Clinton NC^{w}	Lesion Size: C.Hayne NC^{v}	Sporulation: Clinton NC^{u}	Sporulation: C.Hayne NC^{t}
M 21	NC StateUniv	3.8	7.7	7.8	8.8	1.3	1.8
Poinsett 76	Cornell Univ	3.9	.	8.8	9.0	1.5	1.5
Fanfare	Seminis	3.9	.	8.8	8.6	1.8	2.3
Wautoma	Wis-USDA	3.9	9.0	8.4	9.0	2.8	2.0
Picklet	Seminis	4.0	9.0	7.8	8.8	1.8	2.3
WI 2757	USDA-Wis	4.1	.	8.8	8.4	1.8	2.3
Calypso	NC StateUniv	4.2	9.0	9.0	8.8	1.3	1.5
NC-Davie	ZeraimGedera	4.2	9.0	8.0	8.6	2.8	2.8
Eureka	Seminis	4.2	9.0	7.8	8.6	1.8	1.5
HM 82	Harris Moran	4.2	9.0	8.4	8.4	1.3	3.3
MacArthur	Nunhems	4.2	9.0	8.4	8.8	3.3	4.5
Pony	Seminis	4.2	9.0	9.0	9.0	1.8	1.8
Mopick	United Gen.	4.3	9.0	9.0	8.4	2.3	1.5
Vlasstar	Seminis	4.3	9.0	8.6	9.0	1.8	2.8
Slice	Clemson Univ	4.4	9.0	8.8	9.0	1.3	1.5
Cross Country	Harris Moran	4.4	.	8.8	8.6	1.8	1.8
Fancipak	Seminis	4.4	9.0	8.8	8.6	2.5	2.0
Moxie	Harris Moran	4.4	9.0	9.0	9.0	2.0	3.3
Excel	Seminis	4.4	9.0	8.2	9.0	1.0	2.0
Invasion	Western	4.4	9.0	8.6	8.8	2.3	2.8
Stallion	Seminis	4.4	9.0	8.0	8.4	2.5	1.5
Cates	Nunhems	4.4	9.0	7.8	8.8	1.8	2.8
Powerpak	Seminis	4.4	9.0	8.4	9.0	2.3	2.0
Lafayette	Nunhems	4.5	8.0	8.8	8.8	1.8	1.8
Impact	Western	4.5	9.0	8.8	9.0	3.0	3.3
Wainwright	Nunhems	4.5	9.0	8.4	8.8	1.8	3.5
Pershing	Nunhems	4.5	9.0	8.6	9.0	2.0	3.5
Stonewall	Harris Moran	4.5	9.0	8.4	8.4	1.8	3.5
Diamante	Harris Moran	4.5	9.0	9.0	8.8	1.8	2.3
Feisty	Harris Moran	4.5	9.0	8.8	8.8	3.0	2.5
Homegreen #2	USDA-Wis	4.5	9.0	9.0	7.2	4.0	2.5
Europick	United Gen.	4.5	9.0	8.6	8.6	2.5	1.5
HM 81	Harris Moran	4.6	9.0	8.8	9.0	2.8	2.0
Arabian	Seminis	4.6	9.0	8.4	8.2	2.3	3.0
Classy	Harris Moran	4.6	9.0	8.6	8.2	1.8	2.3
Journey	Seminis	4.6	9.0	8.8	9.0	2.0	1.8
Gy 4	NC StateUniv	4.6	9.0	8.6	8.2	1.8	1.0
Starex	Baker	4.6	9.0	9.0	8.8	2.0	2.3
Wellington	Seminis	4.6	9.0	8.4	8.6	1.5	1.5
NC-Duplin	NCState Univ	4.7	9.0	7.8	8.6	2.0	2.8
H-19	UnivArkansas	4.7	9.0	8.2	9.0	2.0	1.8
Nun 5054 PU F1	Nunhems	4.7	5.0	7.8	8.8	1.0	2.3
Expedition	Seminis	4.7	9.0	8.8	9.0	1.8	2.5

Table 2.19 Continued

Spunky	Harris Moran	4.7	9.0	8.6	8.2	3.0	3.8
Vlaspik	Seminis	4.8	9.0	8.8	8.8	1.5	3.3
Colt	Seminis	4.8	9.0	8.4	8.6	1.3	2.5
Sassy	Harris Moran	4.8	9.0	9.0	8.8	2.3	2.8
NongChen#4	PR China	4.9	8.0	6.2	8.0	2.0	4.5
Navigator	Seminis	4.9	9.0	8.2	8.8	3.5	2.3
Jackson(3540)	Nunhems	4.9	9.0	8.6	9.0	3.0	2.8
Vlasspear	Seminis	4.9	9.0	8.6	8.8	1.3	3.0
Nun 5053 PU F1	Nunhems	4.9	5.0	9.0	8.6	3.0	2.0
Heidan#1 (I,R)	PR China	5.0	5.0	4.4	4.6	1.8	3.0
Ballerina	Nunhems	5.0	9.0	8.8	8.4	1.8	1.8
Marketmore 76	Cornell Univ	5.0	.	9.0	8.8	2.3	3.0
Vlasset	Seminis	5.0	9.0	9.0	8.8	1.8	1.5
Tablegreen 72	Cornell Univ	5.1	.	9.0	8.8	3.3	2.0
Dasher II	PetoSeed	5.1	9.0	9.0	8.8	2.8	4.0
Sumter	Clemson Univ	5.1	9.0	9.0	8.4	2.5	2.8
NC-Stratford	NC StateUniv	5.2	9.0	8.6	8.4	3.3	2.0
Greensleaves	Harris Moran	5.2	9.0	8.8	8.6	2.5	4.3
General Lee	Harris Moran	5.3	9.0	9.0	8.6	2.5	4.0
Talladega	Seminis	5.3	9.0	8.8	8.6	1.8	4.0
Indy	Seminis	5.4	9.0	9.0	9.0	3.0	6.0
Atlantis	Bejo Seeds	5.4	9.0	9.0	8.6	2.3	2.5
NC-Sunshine	NC StateUniv	5.4	9.0	8.6	8.4	2.8	2.5
Thunder	Seminis	5.5	9.0	8.7	8.8	2.8	2.8
Papillon	Seminis	5.5	9.0	9.0	8.8	2.8	2.0
Ashley	Clemson Univ	5.5	9.0	8.8	9.0	1.8	3.0
Panther	Nunhems	5.6	9.0	9.0	8.8	3.5	3.5
Nun 5052 PU F1	Nunhems	5.6	5.0	7.4	8.2	2.3	2.8
Speedway	Seminis	5.6	9.0	9.0	8.6	3.8	4.8
Intimidator	Seminis	5.7	9.0	8.6	8.6	1.8	4.3
Montebello	United Gen.	5.7	9.0	8.8	8.6	4.5	5.5
Palomino	Seminis	5.9	9.0	9.0	9.0	3.5	2.8
Straight 8	NSSL	6.1	9.0	9.0	9.0	3.5	3.8
Wis.SMR 18	WisconsinAES	6.2	9.0	9.0	9.0	4.5	2.8
Coolgreen	Asgrow Seed	6.8	.	9.0	9.0	5.0	6.0
LSD (5%)		0.6	0.6	0.7	0.7	1.9	2.1

z Lesion size was rated broadly into three categories (small(1), medium(5), large(9)): small necrotic flecks (1), medium chlorotic and necrotic lesions (5), and large lesions (9) which tended to be mostly chlorotic. Sporulation was rated on the 0 to 9 scale described in Table 2.1.

y Downy mildew mean was the mean of all chlorosis and necrosis ratings at all locations in 2009

x Data is one rating from Bath, Michigan in 2009.

w Data is mean of five ratings from Clinton, North Carolina in 2009.

v Data is mean of five ratings from Castle Hayne, North Carolina in 2009.

u Data is one rating from Clinton, North Carolina in 2009.

t Data is one rating from Castle Hayne, North Carolina in 2009.

Table 2.20. Total yield in Mg/ha and percent marketable fruit for North Carolina and Michigan locations in 2008-2009[z].

Cultivar or line	Mean Tot. Mg/ha	Year and Location: 08 NC-CH[y] Tot. Mg/ha	08 NC-CH[y] % Mrk.	09 NC-CI[x] Tot. Mg/ha	09 NC-CI[x] % Mrk.	09 MI-LS[w] Tot. Mg/ha	09 MI-LS[w] % Mrk.
WI 1983	14.8	14.8	45	.	.	.	.
Nun 5054 PU F1	13.6	18.1	60	13.9	71	13.8	76
Nun 5052 PU F1	13.5	.	.	16.5	79	18.1	95
Nun 5053 PU F1	12.9	9.0	56	20.3	87	16.0	90
Cates	12.5	11.8	47	25.6	64	5.3	71
Starex	10.7	12.0	51	23.8	63	1.7	58
Pony	9.4	9.1	50	20.0	72	1.4	72
Vlasspear	8.9	10.4	58	15.4	64	4.2	83
Classy	8.8	7.1	32	18.4	72	2.6	58
Fancipak	8.5	8.6	73	17.0	56	2.1	89
Spunky	8.4	5.5	27	19.6	68	3.9	35
Ballerina	8.1	.	.	12.4	73	6.1	93
Vlaspik	7.9	10.2	32	14.8	51	2.4	71
Lafayette	7.8	8.1	45	15.9	60	4.1	80
Journey	7.4	4.7	43	15.6	68	3.6	52
Stallion	7.4	7.7	32	16.1	66	3.1	59
Atlantis	7.3	8.7	36	12.9	58	5.5	95
NC-Davie	7.1	5.9	40	15.4	69	0.4	44
Vlasstar	6.9	3.5	27	12.4	60	2.8	73
Powerpak	6.9	6.7	49	12.0	63	4.6	71
Expedition	6.8	6.6	49	13.0	68	3.6	60
Papillon	6.6	5.3	38	13.7	75	3.3	65
NongChen#4	6.5	0.2	0	16.9	58	1.2	36
Indy	6.5	0.6	42	20.0	54	2.1	49
Thunder	6.5	5.0	32	13.1	57	2.6	59
Palomino	6.4	5.4	33	12.5	45	4.2	51
Mopick	6.2	.	.	13.6	43	2.2	71
Wainwright	6.1	0.0	.	16.1	50	3.9	69
Feisty	6.0	6.1	59	10.8	46	3.8	79
M 21	6.0	4.0	32	13.7	71	0.5	32
Arabian	5.9	4.6	51	14.3	70	2.3	53
Calypso	5.8	6.3	33	10.5	59	0.0	.
NC-Stratford	5.4	3.7	19	14.1	61	1.6	53
Wellington	5.3	4.7	38	11.1	74	1.8	89
Navigator	5.3	3.2	25	14.4	87	2.3	90
Greensleaves	5.3	4.9	37	13.0	63	1.2	15
Excel	5.2	2.9	71	10.4	55	3.3	51
Jackson(3540)	5.1	4.0	38	10.7	56	2.7	95
General Lee	5.0	4.0	39	12.2	62	1.5	47
Colt	4.8	2.9	17	11.3	74	2.1	61
Montebello	4.6	.	.	11.8	53	0.6	63

Table 2.20 Continued

Moxie	4.6	3.6	17	9.1	27	4.3	46
Heidan#1 (I,R)	4.3	0.0	.	6.2	64	0.0	.
Talladega	4.3	4.8	19	6.7	56	3.9	55
NC-Duplin	4.2	2.6	40	9.2	41	1.8	90
Europick	4.2	.	.	10.1	57	0.8	86
Diamante	4.1	4.4	6	10.5	61	0.2	0
Cross Country	4.1	4.8	27	10.7	50	0.0	.
Intimidator	4.1	2.8	24	4.7	46	3.0	36
Sassy	4.0	3.9	42	6.9	51	3.4	78
Picklet	4.0	2.1	20	8.4	80	1.1	100
Impact	4.0	2.6	2	9.4	74	1.4	36
Gy 4	3.7	4.2	18	6.2	68	1.5	49
Vlasset	3.5	0.7	25	9.4	58	1.8	86
Invasion	3.4	.	.	8.5	43	0.5	0
Stonewall	3.4	1.5	9	9.9	40	0.4	25
Eureka	3.4	3.2	41	8.9	58	0.0	100
NC-Sunshine	3.4	6.0	42	2.9	17	0.3	0
MacArthur	3.2	4.7	41	4.1	27	1.4	72
Dasher II	3.1	4.3	12	5.6	14	1.5	46
Pershing	3.1	1.2	21	7.7	34	1.8	53
Speedway	3.1	.	.	6.4	33	2.4	28
HM 81	3.0	2.2	25	6.0	35	1.4	70
Panther	2.6	3.9	17	5.6	22	0.5	83
Slice	2.3	1.8	7	6.3	35	0.0	.
HM 82	2.2	1.9	16	3.6	25	1.4	58
Ashley	1.7	2.7	24	2.7	0	0.0	.
Poinsett 76	1.6	1.2	13	4.0	49	0.0	.
LJ 90430	1.5	0.0	.	5.3	92	0.5	0
Fanfare	1.3	0.3	0	4.5	34	0.1	0
WI 4783	0.9	0.9	17	.	.	.	.
Wautoma	0.8	0.0	.	2.2	32	0.6	100
WI 2757	0.7	0.1	0	2.0	44	0.0	.
Sumter	0.6	0.3	7	1.4	0	0.3	100
H-19	0.4	0.0	.	0.7	79	0.0	.
Marketmore 76	0.2	0.0	.	0.7	0	0.0	.
NC-Danbury	0.1	0.1	0	.	.	.	.
NationlPcklng	0.1	0.1	0	.	.	.	.
Wis.SMR 18	0.1	0.1	0	0.4	36	0.0	.
Tablegreen 72	0.0	0.0	.	0.1	100	0.0	.
TMG-1	0.0	0.0	.	.	.	.	.
M 41	0.0	0.0	.	.	.	.	.
WI 2238 (R,S)	0.0	0.0	.	.	.	.	.
Homegreen #2	0.0	0.0	.	0.0	.	0.0	.
Straight 8	0.0	0.0	.	0.0	.	0.0	.
Coolgreen	0.0	0.0	.	0.0	.	0.0	.
LSD (5%)	4.9	4.2	31	9.1	30	2.9	39

z Data is from two harvests for each year, location.
y Data is from Castle Hayne, NC, 2008.

Table 2.20 Continued

w Data is from Clinton, NC, 2009.

v Data is from Bath,MI, 2009.

Chapter Three

Effect of host plant resistance and fungicides in the on severity of downy mildew in cucumber

Adam D. Call, Todd C. Wehner, Gerald Holmes and Peter Ojiambo

Effect of Host Plant Resistance and Fungicides to On Severity of Downy Mildew in Cucumber

Adam D. Call and Todd C. Wehner

Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Gerald Holmes and Peter Ojiambo

Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7609

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[1] Graduate research assistant and professor, former professor (currently Product Development Manage, Valent) and assistant professor, respectively. The authors gratefully acknowledge the technical assistance of Tammy L. Ellington.

Additional index words: *Cucumis sativus, Pseudoperonospora cubensis,* Disease

Abstract

Downy mildew, caused by the oomycete pathogen *Pseudoperonospora cubensis* (Berk. And Curt) Rostov, is a major foliar disease of cucumber (*Cucumis sativus* L.) (Palti and Cohen, 1980). Chemical control of downy mildew is necessary to achieve high yield in the absence of high resistance. Currently, high yield and quality in the presence of downy mildew is achieved with multiple fungicide applications. Most of the currently grown cultivars have some resistance to downy mildew. Prior to the resurgence of the disease in 2004 outbreak, this resistance was sufficient to control the disease, and downy mildew was only a minor problem on cucumber. There are currently no cultivars that show resistance at a level equal to that seen prior to 2004. However, differences in resistance among cultivars

exist, ranging from moderately resistant to highly susceptible. Therefore, both host resistance and fungicides contribute to control of downy mildew for growers. To achieve maximum yield both a resistant cultivar and fungicide spray program should be used. In this study, we evaluated different fungicide treatments, chosen to represent different levels of efficacy, combined with different levels of resistance (resistant - M 21, moderate - 'Sumter', susceptible - 'Wisconsin SMR-18') in cultigens for the effect on disease severity and yield. There were six and twelve replications in 2008 and 2009, respectively. Cultigen had a large effect in both years. Fungicide has a smaller effect on resistance component traits and larger effect on total yield and percent marketable yield. In 2009, the lowest chlorosis rating was the 'Presidio and Bravo alternating with Ranman and Manzate' fungicide treatment on resistant cultivar M 21 with a mean of 2.2 on the 0-9 disease scale. This combination was significantly better than all other combinations in 2009 (LSD 5%= 0,5). The top yielding combination in 2009 was the 'Presidio and Bravo alternating with Ranman and Manzate' fungicide treatment treatment on moderately resistant 'Sumter', with 94.5 Mg/ha. The second highest yielding combination was the same fungicide on M 21, with 81.2 Mg/ha (LSD 5%= 0,5). Over all cultivars, ‘Presidio and Bravo alternating with Ranman and Manzate' outperformed ‘Bravo and Previcure Flex alternating with Manzate and Tanos’ for yield and overall disease. Both of these treatments outperformed ‘Manzate’ and the control (no fungicide) for yield.

Introduction

Downy mildew, caused by the oomycete pathogen *Pseudoperonospora cubensis* (Berk. And Curt) Rostov, is a major foliar disease of cucumber (*Cucumis sativus* L.) (Palti and Cohen, 1980). Studies on the host range of *P. cubensis* indicate that approximately 20 genera, including 50 species in the Cucurbitaceae to be hosts, of which 19 host species are in *Cucumis* (Palti and Cohen, 1980; Lebeda, 1992; Lebeda and Widrlechner, 2003). In 2008 in the United States, 61,399 hectares of cucumbers for processing and fresh market were grown, with a value of $421,222,000 (USDA, 2009). In North Carolina, 7,284 hectares were planted with a value of $25,286,000. Other economically important hosts of *P. cubensis* are melon (*Cucumis melo* L.), watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai), and squash (*Cucurbita* spp.) (Whitaker and Davis, 1962). Downy mildew infects via windblown sporangia, which land on the leaf surface.

P. cubensis is an obligate biotroph, surviving only on living host tissue. In warm production regions, such as southern Florida, overwintering occurs on wild and cultivated cucurbits (Bains and Jhooty, 1976). Overwintering is also possible on cucumbers grown in greenhouses. Hausbeck (2007) reported *P. cubensis* on greenhouse cucumbers in Ontario, Canada in 2006 and 2007. Environmental conditions affect overwintering capacity as well as disease development and intensity. Leaf moisture is required for germination of sporangia. Rain, dew, and irrigation easily supply enough moisture for the sporangia to germinate. Under optimum temperature, infection can occur with only two hours of leaf wetness (Cohen, 1977). The level of infection for compatible reactions is a result of the combination of time, moisture, temperature, and inoculum concentration. Inoculum concentration is affected by many factors such as weather, location, proximity to source, cultivar, fungicide effectiveness, and area affected.

Symptoms of cucumber downy mildew generally occur only on the foliage. Infection first appears as small, water-soaked lesions on the underside of leaves. Lesions are often angular, being bounded by leaf veins, and turning chlorotic to varying degrees. Sporulation occurs on the undersides of the leaves. Chlorotic lesions eventually turn necrotic, and the entire leaf may be overcome by the pathogen and the leaf tissue dies. Symptoms vary depending on relative susceptibility of the cultigens. The most resistant will exhibit a hypersensitive response (HR) with small necrotic or chlorotic flecks and sparse sporulation, while the most susceptible will completely succumb to the disease within a few weeks. The HR type resistance was first described by Barnes and Epps (1954) in the accession PI 197087. Resistance from PI 197087 was used to develop resistant cultivars, and most current cultivars are thought to have some resistance derived from PI 197087. This resistance proved effective for many years, but has since been overcome. Bains (1991) described four categories of lesion types: 1-faded green to dull yellow lesions, size restricted, slow necrosis; 2-yellow spots or flecks, non-angular, slow growing, slow necrosis; 3-bright yellow, large, angular, fast growing, susceptible type, high sporulation; and 4-necrotic spots or flecks, non-angular, little chlorosis, HR type. In a separated study, most lesion types on current cultivars resembled category 3 (Personal observation and unpublished data). The determinate pickle M 21 resembled category 1. ‘Heidan #1’ showed lesion type 2.

Chemical control of downy mildew is necessary to achieve high yield in the absence of high resistance. Jenkins (1942) mentioned "various sprays and dusts have been recommended" to control downy mildew and some copper dusts were partially successful. Jenkins (1946) also reported that most commercial growers use dust or spray fungicides, but control was not satisfactory. Barnes (1948) introduced the cultivar 'Palmetto' in 1948, which could be grown in areas having downy mildew epidemics without requiring fungicide applications. Barnes and Epps (1950) later reported on the use of Dithane fungicide in some studies. Dithane is the trade name for Manzate fungicide. In these studies, susceptible cultivar 'Marketer' produced roughly twice the yield when treated with Dithane compared to an unnamed "less effective" fungicide. For the resistant cultivar 'Palmetto', an increase of 7% in fruit number was found when treated with Dithane compared to the unnamed treatment. 'Results of 1954 fungicide tests,' published in 'Agricultural Chemicals', states that maneb or zineb sprays and dusts were effective in South Carolina against cucumber downy mildew as well as anthracnose (1955). Sowell (1958) reported nabam plus zinc sulfate as giving excellent control and high yield. Zineb was equal to nabam+$MnSO_4$ in disease control but yielded less in one season. Maneb and nabam+$MnSO_4$ also yielded lower than nabam+$ZnSO_4$. The discovery of systemic fungicides was a major advance over protective fungicides in control of downy mildew. Systemic fungicides, in the absence of resistant biotypes, can provide effective control, for a cost. Eschet and Dinur (1970) reported downy mildew on test plots with Benlate (benomyl), stating indications of resistance to benomyl in downy mildew have been observed. Cohen (1979) reported on the effectiveness of two new systematic fungicides, prothiocarb (Previcur) and propamacarb (derivative of prothiocarb) against downy mildew. Both prothiocarb and propamacarb were reported to have very good activity against downy mildew. At the Fifth Congress of the Mediterranean Phytopathological Union in 1980, Pappas (1981) reported good control of *P. cubensis* by phosetyl-Al, under conditions favoring disease. Metalaxyl was reported as less effective and also was shown to have resistant or insensitive biotypes.

Resistance to systemic fungicides has been reported by many authors (Pappas, 1982; Cohen and Samoucha, 1984; Baines and Sharma, 1986; Ishii et all, 2001). Cross resistance was reported by Cohen and Samouch (1984) such that four systemic fungicides were not effective against strains of *P. cubensis* that were resistant to metalaxyl. This loss of fungicide efficacy has lead to strategies to developed reduce selection intensity on pathogens, such as alternating fungicides each application with fungicides having differing modes of action. Effective treatments use alternating modes of action of a protectant and systemic fungicide mixture, such as Previcur Flex and Bravo alternating with Tanos and Manzate. The development of fungicides with different modes of action continues, as the threat of a breakdown in efficacy is unrelenting. Currently, high yield and quality in the presence of downy mildew is achieved with multiple fungicide applications. Most of the currently-grown cultivars have some resistance to downy mildew. Prior to 2004, this resistance was sufficient to control the disease, and downy mildew was only a minor problem on cucumber. St. Amand and Wehner (1991) estimated an average 2.9% loss per year in yield (value/ha) from 1982 to 1988. The resurgence of the pathogen in 2004 resulted in a 40% loss for cucumber growers (Holmes et al., 2006). Since then, downy mildew has continued to be a major destructive disease of cucumber in the eastern United States. There are currently no cultivars with resistance at a level equal to that seen prior to 2004. However, differences among cultivars do exist, ranging from moderately resistant to highly susceptible. Therefore, both host resistance and fungicides contribute to control of downy mildew for growers. In this study, we evaluated different fungicides with cultivars having different levels of resistance (moderately resistant, slightly resistant, susceptible) for the effect on disease severity and yield. Fungicide treatments were chosen to represent different levels of efficacy.

Materials and Methods

Location and Germplasm

All experiments were conducted at the Horticultural Crops Research Station in Clinton, North Carolina. Three cucumber cultivars differing for downy mildew resistance were used to evaluate severity of disease: M 21 (North Carolina State Univ.), ‘Sumter’ (Clemson Univ.), ‘Wisconsin SMR 18’ (Wisconsin AES).

Previous studies at North Carolina State University identified different levels of resistance among cultivars to cucumber downy mildew (Wehner and Shetty, 1997; Shetty et al, 2002). M 21 has consistently been one of the best cultivars in these studies. It did not perform as well as some highly resistant PI accessions, so was classified as moderately resistant on a scale including: highly resistant (HR), moderately resistant (MR), slightly resistant (SR) and highly susceptible (HS). ‘Wis. SMR 18’ is a susceptible cultivar with consistently high disease ratings, and classified as highly susceptible. ‘Sumter’ has slight resistance, outperforming ‘Wisconsin SMR 18’ but not to the level of M 21 and therefore was classified as slightly resistant.

Fungicide Treatments

Fungicides were applied weekly beginning at first true leaf stage. Fungicide treatments were based on recommendations from the Cucurbit Downy Mildew Forecasting group ("Downy Mildew Control Recommendations"). In 2009 an additional fungicide treatment was added to the experiment, based on the 2008 recommendation. The 2008 recommendation fungicide treatment (high disease control) was Ranman (0.04 L/ha) plus Manzate Pro-Stick (0.37 kg/ha) alternating weekly with Presidio (0.04 L/ha) plus Bravo Weather Stik (0.39 L/ha). The 2007 recommendation fungicide treatment (moderate disease control) was Tanos (0.10 L/ha) plus Manzate Pro-Stick (0.37 kg/ha) alternating weekly with Previcur Flex (0.23 L/ha) plus Bravo Weather Stik (0.39 L/ha). The low-cost treatment (intermediate disease control) will be weekly applications of Manzate Pro-Stick (0.37 L/ha). Fungicide treatments were applied using a CO2-pressurized backpack sprayer equipped with hollow cone nozzles (TXVS-26) delivering 40 gal/A at 45 psi.

Field Inoculation

In the field, no artificial inoculum was used. Plots were exposed to natural epidemics in the course of the growing season. Susceptible cultivar 'Coolgreen' (Asgrow) was used in borders around the field to monitor and increase inoculum in the field. Epidemics were encouraged using overhead irrigation. Plots were planted when border rows displayed major symptoms of disease.

Field Ratings

Weekly ratings were done on a 0 to 9 scale based on percentage of symptomatic leaf area; a method developed by Jenkins and Wehner (1983) (Table 3.1). Chlorosis and necrosis symptoms were rated as the percentage of leaves displaying each. For each rating, leaves from all plants in each plot were examined and given a subjective average value of 0 to 9. Stunting was rated as reduction in plant size relative to the larger cultivars used as checks. It is a rating indicating the ability to grow large and branched. Therefore, even without disease, different genotypes would have different stunting ratings. Nevertheless, it allows us to identify those cultigens which remain large and highly branched under a disease epidemic. In 2008, stunting data were taken only on weeks 4 to 6. Lesion size was rated broadly into three categories: S = small necrotic flecks (possibly hypersensitive response), M = medium chlorotic and necrotic lesions, and L = large angular lesions which were mostly chlorotic. In 2008, lesion size data were taken on the second and third ratings only. In the field, lesion size was rated numerically as 1, 5, and 9 for small, medium and large respectively. Therefore the means of lesion size data are not very useful, except in identifying cultigens with means at low and high extremes. In this case, non-parametric analysis should be used, because for means in the middle of the range it cannot be determined if they were a mix, or consistently rated in the middle, without looking at the data. The data collected for lesion size in the study was not interesting, as all cultivars have large lesions, so this analysis was not done. In 2008, lesion size data were taken on the second and third ratings only.

Experiment Design

Field tests were performed in 2008 and 2009 in Clinton, NC. All cucumbers were grown using recommended horticultural practices as summarized by Schultheis (1990). Fertilizer was incorporated before planting at a rate of 90.6-90.6-90.6 kg/ha (N-P-K) with an additional 33.6 kg N/ha applied at the vine-tip-over stage (four to six true leaves). The field was surrounded by border rows, and spreader rows were spaced every 9 rows in the field. Plots were sprayed on a weekly basis beginning at the 1 to 2 true leaf stage for a total of 7 applications. Plots were hand-seeded on raised, shaped beds with centers 1.5 m apart and plots 1.6 m (2009) or 3.2 m (2008 and 2009) long. Plots were separated at each end by 1.5 m alleys. Two plot lengths were used in 2009 (1.6 m and 3.2 m), each in individual blocks, with the 3.2 m plots planted 12 days after the shorter plots. Yield data for the 1.6 m plots was doubled in the analysis in order to estimate the yield on a 3.2 m plot basis, and to compare with the rest of the study. There was likely a border effect on yield as shown by Wehner (1984) indicating the estimate obtained by doubling will be biased slightly upwards. Because this is equal for all treatments, there will be no rank change, and because these were not yield trials, this bias is acceptable. Three cultigens differing for resistance to downy mildew were grown under heavy downy mildew incidence in the field. Three (2008) and four (2009) fungicide treatments were used with each cultigen. The experiment was a split-plot design with fungicide as the whole plot, cultigen as subplot, and six replications. Data were analyzed using the General Linear Model, Means and Correlation procedures of SAS (SAS Institute, Inc., Cary, NC).

Results and Discussion

Data were analyzed using means of all ratings for each trait, based on larger F ratios and smaller coefficient of variation (Table 3.3). Over both years combined, without the Ranman and Presidio treatments, there was a significant cultigen, fungicide, and fungicide by year effect for chlorosis, necrosis, stunting, and lesion size (Table 3.4). Both cultigen and fungicide had a significant effect for chlorosis, necrosis, and lesion size. Fungicide showed its biggest effect on stunting. Cultigen by year was significant for all disease component traits except stunting. Year effect had a high mean square (155.11, 1 df) for lesion size. This was likely due to rating error. The idea to add this component to our ratings occurred in the field in 2008, without a scale of predefined ratings, which were developed for the 2009 season. The difference in years was probably due to slight refinement of the rating scale from the original to the now standard form. It is interesting that the year effect was significant for chlorosis, but not for necrosis. These traits were highly correlated and were likely measuring the same trait.

Significant effects on total yield and percentage marketable yield were found from year, fungicide, and cultigen (Table 3.5). The year effect was likely due to the fact that plots were not grown to optimize yield, causing the environment to have a greater influence on yield traits. Cultigen was the only significant effect on percentage early fruit.

Data were analyzed with years combined (for fungicide treatments included in both years) and for years separately (2008: 3 fungicide treatments, 2009: 4 fungicide treatments). In 2008, the cultigen and fungicide effects were significant for chlorosis, necrosis, stunting and lesion size (Table 3.6). Cultigen also had a significant effect on total yield, percentage marketable yield, and percentage early yield. There was also a significant cultivar by fungicide interaction for total yield (Table 3.7). The fungicide effect was only significant for total yield.

In 2009, there was a significant cultigen effect for all downy mildew resistance components rated (Table 3.8). Fungicide showed a significant effect on all traits except lesion size. Fungicide and cultivar showed a highly significant effect on total and percentage marketable yield in 2009 (Table 3.9). The average fruit weight was significantly affected by fungicide as well. The use of a resistant cultivar combined with a highly effective fungicide can influence yield traits greatly.

All correlations were calculated using the Pearson product-moment and Spearman's rank methods. Correlations for both 1.5 m (2009) and 3 m (2008 and 2009) plots are shown for 2009 (Table 3.10) for total yield, marketable yield, and mean chlorosis rating. All combinations were significant at a minimum of $p=0.01$.

Correlation of disease traits was measured using the mean of all ratings for over environments (Table 3.11) for chlorosis, necrosis, stunting and lesion size. Chlorosis and necrosis were highly correlated for both the Pearson and the Spearman tests(0.92 and 0.99 respectively), indicating they are likely the same trait. Interestingly, stunting was negatively correlated to all other traits, but only significantly (p=.05) with lesion size using the Pearson correlations. Chlorosis and lesion size were correlated at 0.67 and 0.63 (p=.05) using the Pearson and Spearman correlation respectively.

F-Ratio and coefficient of variation were examined for the means of all component ratings and the means of each weekly rating taken for each year and both years combined (Table 3.3). For chlorosis, necrosis and lesion size, results indicated that the means of all ratings for each trait in each environment were most useful for determining differences among cultigens. These ratings had a higher F-Ratio and lower coefficient of variation than the means of any of the weekly ratings. The F-Ratio and coefficient of variation for stunting, means over all ratings were not as consistent.

For 2008 and 2009 combined and separate, the means of the stunting data taken on the final rating date had the highest F-Ratio and lowest coefficient of variation. This is likely because differences between plots become progressively more apparent as they grow larger. These results indicate that stunting ratings need only be taken on the final few rating dates, saving time and labor. Stunting data were taken on only the final three ratings 2008. Lesion size data were taken on two rating dates in 2008, and four rating dates in 2009.

Disease and yield data for 2008 are summarized in Table 3.12. Cultivars and fungicide performed as expected. The resistant cultivar M 21 on average outperformed the moderately resistant 'Sumter' and susceptible 'Wisconsin SMR-18' in all yield traits and all disease traits with the exception of stunting. M 21 is a determinate type and has a naturally shorter habit than indeterminate types. The Previcure Flex and Bravo alternating with Tanos and Manzate outperformed Manzate alone and untreated tests. For most traits the combination treatment was significantly better than both other fungicide treatments. Similar results were found by Colucci et al (2008), in which all combinations using Previcur flex with alternating treatments outperformed Manzate alone and the control for disease traits.

In 2008, both cultigen and fungicide had an effect on yield. For chlorosis the difference in means for resistant M 21 (2.5) and susceptible 'Sumter' (6.5) is 4 points on the 0-9 scale. The mean chlorosis by fungicides shows a difference of only about 1 point gained by using the combination fungicide over none. The mean yield by fungicides over cultivars was 0.6, 2.2, and 4.5 Mg/ha for control, Manzate, and Previcure Flex and Bravo alternating with Tanos and Manzate treatments respectively. In general the fungicides give a small reduction in apparent disease, but protect a large amount of potential total yield. In a study by Colucci et al (2008), the treatment using Tanos and Manzate alternating with Previcur Flex and Manzate, showed significantly higher yield than Manzate alone, and both treatments were significantly higher than the control.

Results from 2009 are summarized in Table 3.13. In 2009 the new recommended fungicide treatment, Presidio and Bravo alternating with Ranman and Manzate, was added to the test. The general results were similar to those obtained in 2008. The new fungicide treatment showed significantly better control than the other treatments for chlorosis and necrosis and most yield traits. The Tanos combination treatment performed similarly on resistant M 21, but was significantly less effective on 'Sumter' and 'Wisconsin SMR-18' compared to the new treatment. The highest yielding combination in 2009 was the new fungicide treatment on 'Sumter', although overall, M 21 outyielded both 'Sumter' and 'Wisconsin SMR-18'. Improved yield from improved fungicide treatments was seen more in 'Sumter' than in 'Wisconsin SMR-18' or M 21. The resistant M 21 showed higher total yield without fungicide than susceptible 'Wisconsin SMR-18' with the new Presidio combination treatment. Because of the high yield without fungicides, the gain possible with fungicides is limited. Susceptible cultivar 'Wisconsin SMR-18' showed high disease ratings even with fungicides, so yield range is still limited by disease. The moderately resistant 'Sumter' showed the largest range in fungicide response. This is due to good performance with the top fungicides, and poor performance without fungicides.

The most effective treatment was the Presidio-Ranman combination (2009 only) followed by the Previcure combination, Manzate and no fungicide treatments. Combined analysis results for 2008 and 2009 without the Presidio-Ranman combination (2009 only) fungicide treatment are shown in Table 3.14. Results follow the same trends outlined above. Cultigen resistance levels corresponded to disease levels and yield levels as expected. Fungicide treatment reduces disease component ratings, although the range over cultivars was much smaller than in the range of cultivar treatments over fungicides. Fungicides had a high influence on yield traits, especially on moderately resistant 'Sumter'.

Conclusions

In all years, cultivars behaved as expected in terms of resistance (M 21-resistant, Sumter-moderately resistant, Wis. SMR18-susceptible). It is obvious that a resistant cultigen will outperform a cultigen with less resistance. But even the most resistant cultivars available require fungicides to achieve high yield under disease. Fungicides alone are not enough to achieve high yield in susceptible cultivars, but are effective in combination with a moderately resistant cultivar. Currently, both cultivar resistance and fungicide treatment together contribute to plant performance in terms of disease and yield traits.

Greater range in mean ratings of disease traits were seen for different levels of resistance than for the different fungicide efficacy levels. For yield traits, the ranges were similar for cultivars and fungicides. Cultigen resistance seems to be more important for overall disease reduction than fungicides, but each contributed similarly to yield. It is likely that the benefits of fungicide application would be greater than data indicates in terms of severity of disease in a grower field. In our tests, neighboring plots that were not treated with fungicide may have increased spore density in the field, causing more disease. All borders were untreated and planted with a highly susceptible check as well. A field that is treated with complete fungicide coverage should be less affected, assuming neighboring fields are being controlled as well.

It is interesting that the Tanos-Previcur combination treatment was not significantly better than the Manzate treatment in 2009 for disease. Manzate had means resembling those in 2008, while the Tanos combination treatment showed an increase in means. There may be some loss of efficacy in Tanos and Previcur Flex since 2008. In a study by Kanetis et al (2009) in 2008, conducted in Clayton, NC, Previcur Flex was significantly better than both Tanos and Manzate using area under disease progress curve (AUDPC), which were not significantly different. In 2009 a study from the same group (Adams and Ojiambo, 2010) at the same location, showed Manzate and Previcur flex (not significantly different) had a significantly lower AUDPC than Tanos. At a different location (Faison, NC) in 2009, (Adams et al, 2010), the Manzate treatment had a significantly lower AUDPC than both Previcur Flex and Tanos. These results may indicate some loss in effectiveness by Tanos and Previcur Flex, though more studies should be done to evaluate this. The Tanos-Previcur combination treatment still significantly outperformed the Manzate treatment for total yield.

In most cases, growers are already using cultivars with resistance comparable to M 21. Until new resistance becomes available, fungicide spray programs will continue to be required in order to achieve to achieve high yield in cucumber where downy mildew is a problem. The currently recommended treatment, 'Presidio and Bravo alternating with Manzate and Ranman', was the best in this study. It is probably not necessary to have the best of the best fungicide treatments. For example growers would likely maintain similar yield with the 'Previcur Flex and Bravo alternating with Tanos and Manzate'. It is clear that cultivars with resistance coupled with an effective fungicide program are required to achieve high yield at this time. To achieve high yield without fungicide, more resistance is needed. Another study (unpublished data) showed that there is better resistance available in PI accessions. This could be exploited to reduce or eliminate the need for fungicide treatments in cucumber production.

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Table 3.1. Subjective rating scale for field assessment of foliar resistance to downy mildew in cucumber for chlorosis and necrosis.

Subjective Rating	Percent of leaf area affected by chlorosis or necrosis	Description of symptoms
0	No symptoms	No symptoms
1	1-3	Trace
2	3-6	Trace
3	6-12	Slight
4	12-25	Slight
5	25-50	Moderate
6	50-75	Moderate
7	75-87	Severe
8	87-99	Severe
9	100	Plant dead

Table 3.2. Trade names, active ingredients and supply company for fungicides used in 2008 and 2009.

Trade Name	Active Ingredient	Application Rate	Supply Company
Manzate® Pro-Stick™	mancozeb	0.37 kg/ha	E.I. Dupont de Nemours and Co.
Bravo Weather-Stik®	chlorothalonil	0.39 L/ha	Syngenta Crop Protection, Inc.
Tanos®	famoxadone	0.10 L/ha	E.I. Dupont de Nemours and Co.
Previcur® Flex	propamocarb-hydrochloride	0.23 L/ha	Bayer CropScience
Presidio® [z]	fluopicolide	0.04 L/ha	Valent BioSciences Corporation
Ranman® [z]	cyazofamid	0.04 L/ha	FMC Agricultural Products

z Fungicides used in 2009 only

Table 3.3. F-Ratio and Coefficient of variation for downy mildew component ratings tested in North Carolina in 2008 and 2009[z].

		Chlorosis		Necrosis		Stunting		Lesion Size	
Year	Rating	F	CV	F	CV	F	CV	F	CV
Combined	1	6.13	31.36	3.02	31.75	-	-	-	-
2008-2009 [y]	2	18.64	17.95	5.03	25.57	-	-	4.80	17.25
	3	14.19	19.85	5.83	22.05	-	-	1.64	15.82
	4	10.46	16.84	5.28	19.08	1.94	25.25	-	-
	5	9.09	22.84	2.31	25.53	5.82	25.90	-	-
	Avg	27.94	11.60	8.02	12.59	4.09	20.29	6.69	10.66
2008	1	20.65	19.97	0.61	22.67	-	-	-	-
	2	22.60	22.54	1.27	30.14	-	-	3.85	28.72
	3	23.74	20.61	10.41	18.64	-	-	1.47	21.45
	4	13.04	15.06	4.63	14.64	1.44	16.24	-	-
	5	14.42	23.12	7.05	16.99	4.29	33.83	-	-
	6	17.77	10.84	13.90	9.36	7.52	23.13	-	-
	Avg	90.11	7.47	12.21	6.71	6.12	16.87	4.11	18.53
2009	1	5.32	35.5	4.20	39.03	2.83	38.62	1.17	10.63
	2	8.50	19.27	5.86	25.10	2.51	39.28	1.22	11.49
	3	9.72	21.42	5.04	24.60	3.01	33.07	1.21	12.58
	4	11.80	17.34	6.14	20.12	3.05	29.55	1.32	7.05
	5	7.56	22.31	1.59	24.89	3.99	25.46	-	-
	Avg	19.31	13.71	8.92	15.25	4.26	23.55	1.42	6.61

z Data is from six replications in 2008 and 12 replications in 2009.
y Combined years do not contain data from new fungicide treatment in 2009.

Table 3.4. Analysis of variance for downy mildew resistance trait means for data collected in Clinton, North Carolina in 2008 and 2009[z].

		Downy Mildew Resistance Components			
Source	DF	Chlorosis[y] Mean Square	Necrosis[x] Mean Square	Stunting[w] Mean Square	Lesion Size Mean Square
Year	1	19.20 **	0.78	4.77 *	155.11 ***
Rep(Year)	16	1.58	1.81	0.90	0.74
Fungicide	2	3.91 ***	3.13 ***	22.32 ***	4.44 *
Fungicide*Year	2	3.23 ***	4.96 ***	3.83 **	6.29 ***
Fung.*Rep(Year)	32	0.14	0.35	0.76	1.01
Cultigen	2	190.4 ***	59.11 ***	21.30 ***	39.74 ***
Cultigen*Fungicide	4	0.13	0.26	0.58	2.39 *
Cultigen*Year	2	5.16 ***	8.29 ***	1.72	16.72 ***
Cult.*Fung.*Year	4	0.07	0.02	0.51	2.32 *
Error	94	0.27 ***	0.45 ***	0.59 ***	0.74 ***

z Data are means of six (2008) and 12 (2009) replications. The Ranman/Presidio treatment is exluded.
y Data are means or all chlorosis ratings.
x Data are means of all necrosis ratings.
w Data are means of all stunting ratings.
v Data are means of all lesion size ratings.
*,**'*** Significant at 0.05, 0.01 and 0.001 respectively

Table 3.5. Analysis of variance for yield traits for data collected in Clinton, North Carolina in 2008 and 2009[z].

		Downy Mildew Yield			
Source	DF	Total Mg/ha MS[y]	% marketable MS[x]	% early MS[w]	kg/ fruit MS[v]
Year	1	508.4 ***			
Rep(Year)	16	115.0 ***			
Fungicide	2	261.3 ***			
Fungicide*Year	2	6.2			
Fung.*Rep(Year)	32	8.3			
Cultigen	2	453.8 ***			
Cultigen*Fungicide	4	16.5			
Cultigen*Year	2	31.7			
Cult.*Fung.*Year	4	12.3			
Error	96	11.6 ***			
Year	1		4344 **	1601	
Rep(Year)	16		560	557	
Fungicide	2		1513 **	504	
Fungicide*Year	2		306	155	
Fung.*Rep(Year)	32		314	528	
Cultigen	2		12313 ***	3863 **	
Cultigen*Fungicide	4		46	434	
Cultigen*Year	2		674	442	
Cult.*Fung.*Year	3		896	676	
Error	74		354 ***	585	
Year	1				0.0508 **
Rep(Year)	16				0.0041
Fungicide	2				0.0014
Fungicide*Year	2				0.0019
Fung.*Rep(Year)	32				0.0032
Cultigen	2				0.0040
Cultigen*Fungicide	3				0.0057
Cultigen*Year	2				0.0046
Cult.*Fung.*Year	1				0.0025
Error	49				0.0051

z Data are means of six (2008) and 12 (2009) replications. The Ranman/Presidio treatment is exluded.
y Total yield in Mg/ha.
x Percent marketable yield is percent non-cull fruit.
w Percent early yield is yield from harvest 1 of 2.
v Mean fruit weight in kg.
*,**'*** Significant at .05, 0.01 and 0.001 respectively

Table 3.6. Analysis of variance for downy mildew resistant component mean ratings in Clinton, North Carolina in 2008[z].

		Downy Mildew Resistance Components			
		Chlorosis[y]	Necrosis[x]	Stunting[w]	Lesion Size[v]
Source	DF	Mean Square	Mean Square	Mean Square	Mean Square
Replication	5	0.21	0.08	0.85	1.56
Fungicide	2	4.80 ***	5.90 ***	15.74 ***	8.22 **
Rep.*Fungicide	10	0.07	0.10	0.44	2.44
Cultigen	2	85.26 ***	11.89 ***	4.97 ***	40.67 ***
Cult.*Fung.	4	0.10	0.10	0.04	3.56
Error	30	0.09 ***	0.13 ***	0.81 ***	1.53 ***

z Data are means of six replications.
y Data are means or all chlorosis ratings.
x Data are means of all necrosis ratings.
w Data are means of all stunting ratings.
v Data are means of all lesion size ratings.
*,**'*** Significant at .05, 0.01 and 0.001 respectively

Table 3.7. Analysis of variance for downy mildew yield traits in Clinton, North Carolina in 2008[z].

		Downy Mildew Yield			
Source	DF	Total Mg/ha MS[y]	% marketable MS[x]	% early MS[w]	kg/ fruit MS[v]
Replication	5	3.7			
Fungicide	2	69.5 ***			
Rep.*Fungicide	10	1.5			
Cultigen	2	92.9 ***			
Cult.*Fung.	4	11.4 ***			
Error	30	1.2 ***			
Replication	5		220	279	
Fungicide	2		903	125	
Rep.*Fungicide	10		307	590 **	
Cultigen	2		2350 ***	2098 ***	
Cult.*Fung.	3		325	105	
Error	18		188 ***	128 ***	
Replication	5				0.0014
Fungicide	2				0.0031
Rep.*Fungicide	10				0.0043
Cultigen	2				0.0018
Cult.*Fung.	1				0.0021
Error	11				0.0044

z Data are means of six replications.
y Total yield in Mg/ha.
x Percent marketable yield is percent non-cull fruit.
w Percent early yield is yield from harvest 1 of 2.
v Mean fruit weight in kg.
*,**'*** Significant at .05, 0.01 and 0.001, respectively.

Table 3.8. Analysis of variance for downy mildew resistant component mean ratings in Clinton, North Carolina in 2009[z].

		Downy Mildew Resistance Components			
		Chlorosis[y]	Necrosis[x]	Stunting[w]	Lesion Size[v]
Source	DF	Mean Square	Mean Square	Mean Square	Mean Square
Replication	11	3.14 ***	3.60 ***	1.18	0.37
Fungicide	3	6.39 ***	6.01 ***	11.83 ***	0.07
Rep.*Fungicide	33	0.21	0.47	0.91	0.32
Cultigen	2	168.43 ***	108.99 ***	43.83 ***	5.44 ***
Cult.*Fung.	6	0.12	0.28	1.87	0.05
Error	86	0.38 ***	8.92 ***	0.76 ***	0.33

z Data are means of twelve replications.
y Data are means or all chlorosis ratings.
x Data are means of all necrosis ratings.
w Data are means of all stunting ratings.
v Data are means of all lesion size ratings.
*,**’*** Significant at .05, 0.01 and 0.001 respectively

Table 3.9. Analysis of variance for downy mildew yield traits in Clinton, North Carolina in 2009[z].

		Downy Mildew Yield			
Source	DF	Total Mg/ha MS[y]	% marketable MS[x]	% early MS[w]	kg/ fruit MS[v]
Replication	11	327.66 ***			
Fungicide	3	884.20 ***			
Rep.*Fungicide	33	21.86			
Cultigen	2	575.64 ***			
Cult.*Fung.	6	48.99 *			
Error	88	22.42 ***			
Replication	11		802.85	791.50	
Fungicide	3		5482.75 ***	625.37	
Rep.*Fungicide	33		438.29	425.90	
Cultigen	2		20574.62 ***	2147.82 *	
Cult.*Fung.	6		1671.74 ***	1424.27 *	
Error	78		376.70 ***	613.75	
Replication	11				0.0074
Fungicide	3				0.0351 ***
Rep.*Fungicide	33				0.0027
Cultigen	2				0.0069
Cult.*Fung.	5				0.0074
Error	59				0.0044

z Data are means of twelve replications.
y Total yield in Mg/ha.
x Percent marketable yield is percent non-cull fruit.
w Percent early yield is yield from harvest 1 of 2.
v Mean fruit weight in kg.
*,**'*** Significant at .05, 0.01 and 0.001 respectively

Table 3.10. Pearson product-moment correlation coefficients (above diagonal) and Spearman's rank correlation coefficients (below diagonal) of yield data from Clinton, NC, with 5 ft and 10 ft plots in 2008 and 2009[z].

	Environment (Year x Location)		
	2008	2009	
	Clinton-10ft[y]	Clinton-05ft[x]	Clinton-10ft[w]
Total Mg/ha			
2008			
Clinton-10 ft		0.88**	0.84 **
2009			
Clinton-05 ft	0.92***		0.73***
Clinton-10 ft	0.83**	0.87***	
marketable Mg/ha[v]			
2008			
Clinton-10 ft		0.83**	0.95***
2009			
Clinton-05 ft	0.95***		0.78**
Clinton-10 ft	0.99***	0.97***	
Chlorosis Mean Rating[u]			
2008			
Clinton-10 ft		0.92***	0.94***
2009			
Clinton-05 ft	0.83**		0.97***
Clinton-10 ft	0.85**	0.98***	

z Data are from 2 harvests and four replications. Locations with fungicide received weekly application of Previcure Flex and Manzate alternating with Tanos and Bravo.
y Data is from Clinton, NC, in 2008, 10 ft plots.
x Data is from Clinton, NC, in 2009 , 05 ft plots.
w Data is from Clinton, NC, in 2009, 10 ft plots.
v marketable yield is total non-cull yield in Mg/ha.
u Mean of all chlorosis ratings.
*, **,**Significant at 0.05, 0.01 and 0.001 respectively

Table 3.11. Pearson product-moment correlation coefficients (above diagonal) and Spearman's rank correlation coefficients (below diagonal) of disease traits in Clinton, North Carolina in 2008-2009[z].

Trait	Chlorosis[y]	Necrosis[x]	Stunting[w]	Lesion Size[v]
Chlorosis		0.92***	-0.43	0.67*
Necrosis	0.99***		-0.52	0.56
Stunting	-0.42***	-0.45		-0.66*
Lesion Size	0.63*	0.58*	-0.52	

z Data are from four replications using combined best ratings based on F value.
y Data is mean of all chlorosis ratings.
x Data is mean of all necrosis ratings.
w Data is mean of all stunting ratings.
v Data is mean of all lesion size ratings.
*, **,**Significant at 0.05, 0.01 and 0.001 respectively

Table 3.12. Control of downy mildew in cucumber using host resistance and fungicide application for plants tested in 2008 at Clinton, NC[z].

Cultivar	Fungicide Treatment[y]	Downy mildew rating Chlr.[x] Mean	Necro.[w] Mean	Stunt.[v] Mean	Les.Siz.[u] Mean	Total yield (Mg/ha)	% mark. yield[t]	% early yield[s]	Fruit size[r] (kg/fr)
M 21	Tanos	1.9	4.2	3.4	4.7	8.1	58	41	0.12
	Manzate	2.6	4.7	3.8	6.0	4.8	48	40	0.10
	None	2.8	5.3	5.1	4.7	1.7	23	36	0.07
Sumter	Tanos	2.5	4.6	2.3	7.0	4.5	27	11	0.08
	Manzate	3.1	5.1	2.7	7.7	1.7	14	7	0.10
	None	3.4	6.0	4.2	5.7	0.0	.	.	.
SMR18	Tanos	5.7	5.9	2.8	7.0	1.0	13	9	0.10
	Manzate	6.8	6.3	3.0	8.7	0.2	0	0	.
	None	6.9	6.8	4.5	8.7	0.0	0	0	.
LSD (5%)		0.4	0.5	0.8	1.7	1.5	19	16	0.09
M 21	-	2.5	4.8	4.1	5.1	4.9	43	39	0.10
Sumter	-	3.0	5.2	3.1	6.8	2.0	20	9	0.09
SMR18	-	6.5	6.3	3.4	8.1	0.4	7	5	0.10
-	Prev	3.4	4.9	2.9	6.2	4.5	33	21	0.10
-	Manz	4.2	5.4	3.1	7.4	2.2	23	18	0.10
-	None	4.3	6.0	4.6	6.3	0.6	19	31	0.07

z Data are means of 6 replications of 2 harvests each. Ratings were 0 to 9 (0=no disease, 1-2=trace, 3-4, slight, 5-6=moderate, 7-8=severe, 9=dead) for chlorosis, necrosis and stunting of the plants.
y Fungicide treatments were applied weekly as Tanos alternating with Previcure Flex , Manzate, or nothing.
x Mean of all chlorosis ratings at Clinton, NC in 2008.
w Mean of all necrosis ratings at Clinton, NC in 2008.
v Mean of all stunting ratings at Clinton, NC in 2008.
u Mean of all lesion size ratings at Clinton, NC in 2008. Lesion size was rated as 1,5, or 9 (1=small fleck, 5=small round lesion, 9=large angular lesion).
t Percent marketable yield is total yield that is non-culled fruit.
s % early yield was the percentage of total yield obtained in harvest 1 (out of 2).
r Fruit size was calculated from marketable fruit.

Table 3.13. Control of downy mildew in cucumber using host resistance and fungicide application for plants tested in 2009 at Clinton, NC[z].

Cultivar	Fungicide Treatment[y]	Downy mildew rating Chlr.[x] Mean	Necro.[w] Mean	Stunt.[v] Mean	Les.Siz.[u] Mean	Spor.[t] Mean	Total yield (Mg/ha)	% mark. yield[s]	% early yield[r]	Fruit size[q] (kg/fr)
M 21	Presidio	2.2	2.7	4.6	8.3	1.2	81.2	72	30	0.22
	Tanos	2.9	3.8	4.6	8.4	1.0	79.6	69	34	0.20
	Manzate	2.8	3.6	4.9	8.3	1.7	64.9	68	42	0.17
	None	3.2	3.6	5.1	8.5	1.3	69.0	73	50	0.16
Sumter	Presidio	3.6	4.8	2.2	8.8	1.7	94.5	59	26	0.23
	Tanos	4.6	5.8	2.7	9.0	1.8	72.8	34	34	0.17
	Manzate	4.2	5.5	3.8	8.8	3.5	51.5	27	28	0.14
	None	4.6	5.8	3.7	8.8	2.5	23.5	12	30	0.15
SMR18	Presidio	6.0	6.0	2.3	9.0	3.8	63.3	58	33	0.23
	Tanos	6.7	6.8	2.8	9.0	4.8	38.6	38	45	0.11
	Manzate	6.5	6.4	3.2	9.0	4.8	16.1	34	21	0.16
	None	7.0	6.5	4.3	9.0	4.7	11.7	0	21	.
LSD (5%)		0.6	0.8	0.9	0.6	2.1	4.7	19	25	0.07
M 21	-	2.8	3.4	4.8	8.4	1.3	73.7	70	39	0.19
Sumter	-	4.2	5.5	3.1	8.9	2.4	60.6	33	29	0.18
SMR18	-	6.5	6.4	3.2	9.0	4.5	32.4	36	31	0.17
-	Presidio	3.9	4.5	3.1	8.7	2.2	79.7	63	29	0.23
-	Tanos	4.7	5.4	3.4	8.8	2.6	63.7	48	38	0.16
-	Manz	4.5	5.2	4.0	8.7	3.3	44.2	43	31	0.16
-	None	4.9	5.3	4.3	8.8	2.8	34.7	34	36	0.16

z Data are means of 12 replications of 2 harvests each. Ratings were 0 to 9 (0=no disease, 1-2=trace, 3-4, slight, 5-6=moderate, 7-8=severe, 9=dead) for chlorosis, necrosis, stunting and sporulation of the plants.
y Fungicide treatments were applied weekly as Presidio and Bravo alternating with Ranman and Manzate, 'Tanos and Manzate alternating with Previcure Flex and Bravo, Manzate, or nothing.
x Mean of all chlorosis ratings at Clinton, NC in 2009.
w Mean of all necrosis ratings at Clinton, NC in 2009.
v Mean of all stunting ratings at Clinton, NC in 2009.
u Mean of all lesion size ratings at Clinton, NC in 2009. Lesion size was rated as 1,5, or 9 (1=small fleck, 5=small round lesion, 9=large angular lesion).
t Sporulation data taken on single rating date.
s Percent marketable yield is total yield that is non-culled fruit.
r % early yield was the percentage of total yield obtained in harvest 1 (out of 2).
q Fruit size was calculated from marketable fruit.

Table 3.14. Control of downy mildew in cucumber using host resistance and fungicide application for plants tested in 2008 and 2009 at Clinton, NCz.

Cultivar	Fungicide Treatment[y]	Downy mildew rating Chlr.[x] Mean	Necro.[w] Mean	Stunt.[v] Mean	Les.Siz.[u] Mean	Total yield (Mg/ha)	% mark. yield[t]	% early yield[s]	Fruit size[r] (kg/fr)
M 21	Tanos	2.6	3.9	4.2	7.1	79.3	65	36	0.17
	Manzate	2.8	4.0	4.5	7.5	63.1	62	41	0.15
	None	3.0	4.2	5.1	7.2	56.2	56	45	0.13
Sumter	Tanos	3.8	5.3	2.6	8.3	69.8	31	26	0.14
	Manzate	3.9	5.3	3.4	8.4	43.0	22	21	0.13
	None	4.2	5.9	3.9	7.8	15.7	12	30	0.15
SMR18	Tanos	6.3	6.5	2.8	8.3	31.2	30	33	0.11
	Manzate	6.6	6.4	3.1	8.9	12.1	24	15	0.16
	None	6.9	6.6	4.3	8.9	7.9	0	18	.
LSD (5%)		0.4	0.5	0.6	0.7	2.8	15	20	0.06
M 21	-	2.7	3.8	4.6	7.5	68.9	63	39	0.16
Sumter	-	3.9	5.4	3.1	8.3	52.2	31	25	0.16
SMR18	-	6.5	6.4	3.2	8.8	25.5	30	25	0.16
-	Tanos	4.2	5.2	3.2	7.9	60.1	43	32	0.14
-	Manz	4.4	5.2	3.7	8.3	39.4	37	27	0.14
-	None	4.7	5.5	4.4	8.0	26.6	31	35	0.13

z Data are means of 6 replications of 2 harvests each. Ratings were 0 to 9 (0=no disease, 1-2=trace, 3-4, slight, 5-6=moderate, 7-8=severe, 9=dead) for chlorosis, necrosis and stunting of the plants.

y Fungicide treatments were applied weekly as Tanos alternating with Previcure Flex , Manzate, or nothing (The Ranman/Presidio treatment is exluded.).

x Mean of all chlorosis ratings at Clinton, NC in 2008 and 2009.

w Mean of all necrosis ratings at Clinton, NC in 2008 and 2009.

v Mean of all stunting ratings at Clinton, NC in 2008 and 2009.

u Mean of all lesion size ratings at Clinton, NC in 2008 and 2009. Lesion size was rated as 1,5, or 9 (1=small fleck, 5=small round lesion, 9=large angular lesion).

t Percent marketable yield is total yield that is non-culled fruit.

s % early yield was the percentage of total yield obtained in harvest 1 (out of 2).

r Fruit size was calculated from marketable fruit.

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APPENDIX

Appendix Table 1. Cucumber germplasm screening ranked from most to least downy mildew resistant by rating three (taken five weeks after planting) with standard deviation, means of rating three in North Carolina and Poland and number of missing replications.

Rank	Cultigen	Seed Source	Rating 3 Total[z]	SD	Rating 3 NC[y]	Rating 3 Poland[x]	Missing replications[w]
1	PI 197088	India	1.0	1.1	1.7	0.3	0
2	Ames 2354	United States	1.0	0.9	1.7	0.3	0
3	PI 267942	Japan	1.0	-	-	1.0	5
4	Ames 2353	United States	1.0	0.9	1.7	0.3	0
5	PI 197085	India	1.2	1.2	1.3	1.0	0
6	PI 330628	Pakistan	1.2	1.2	2.0	0.3	0
7	PI 432878	P.R. China	1.3	1.2	1.7	1.0	0
8	PI 618931	P.R. China	1.3	1.2	2.0	0.0	3
9	PI 234517	United States	1.3	1.2	2.3	0.3	0
10	PI 605996	India	1.3	1.0	1.0	1.7	0
11	PI 321008	Taiwan	1.5	1.4	2.7	0.3	0
12	PI 432875	P.R. China	1.5	1.2	2.0	1.0	0
13	Poinsett 76	Cornell Univ.	1.6	1.3	3.0	0.7	1
14	PI 432882	P.R. China	1.7	1.4	2.3	1.0	0
15	PI 618937	P.R. China	1.7	1.4	2.3	1.0	0
16	PI 605924	India	1.7	1.5	2.7	0.7	0
17	Ames 7752	United States	1.7	1.5	2.5	0.0	3
18	PI 197086	India	1.8	1.3	1.7	2.0	0
19	PI 321009	Taiwan	1.8	2.6	3.3	0.3	0
20	PI 432886	P.R. China	1.8	1.7	2.7	1.0	0
21	PI 532162	Oman	2.0	1.4	-	2.0	4
22	PI 605932	India	2.0	0.9	2.3	1.7	0
23	PI 432874	P.R. China	2.0	2.3	3.7	0.3	0
24	PI 390267	Japan	2.0	1.7	3.0	1.0	0
25	PI 432885	P.R. China	2.0	2.0	3.7	0.3	0
26	PI 606015	India	2.0	1.6	3.0	0.5	1
27	PI 605929	India	2.2	1.5	3.0	1.3	0
28	Homegreen #2	USDA-Wis	2.2	1.7	3.3	1.0	0
29	PI 432877	P.R. China	2.2	2.4	4.0	0.3	0
30	PI 518849	P.R. China	2.2	1.9	3.3	1.0	0
31	PI 618893	P.R. China	2.2	1.5	3.0	1.3	0
32	PI 618869	P.R. China	2.2	2.4	1.3	3.0	0
33	PI 511820	Taiwan	2.2	1.1	3.0	1.7	1
34	PI 618948	P.R. China	2.2	1.6	3.3	0.5	1
35	PI 390251	Japan	2.2	1.1	3.0	1.7	1

Appendix Table 1 Continued

36	Gy 4	NC State Univ.	2.3	0.8	2.3	2.3	0
37	PI 426170	Philippines	2.3	1.2	2.7	2.0	0
38	PI 390246	Japan	2.3	2.2	4.0	0.7	0
39	PI 508455	South Korea	2.3	1.8	3.3	1.3	0
40	PI 385967	Kenya	2.3	1.4	2.7	2.0	0
41	PI 200815	Myanmar	2.4	1.3	3.5	1.7	1
42	PI 605928	India	2.5	2.4	2.3	2.7	0
43	PI 418962	P.R. China	2.5	1.2	3.0	2.0	0
44	WI 2757	USDA-Wis	2.5	1.7	3.5	1.5	2
45	PI 618892	P.R. China	2.5	0.8	2.7	2.3	0
46	PI 432854	P.R. China	2.5	1.6	3.7	1.3	0
47	PI 391570	P.R. China	2.5	1.2	3.3	1.7	0
48	Ames 26049	Sri Lanka	2.6	2.6	1.7	4.0	1
49	PI 418963	P.R. China	2.6	2.3	4.5	1.3	1
50	PI 606017	India	2.6	2.7	4.0	0.5	1
51	PI 432881	P.R. China	2.6	1.8	3.7	1.0	1
52	PI 500366	Zambia	2.6	1.5	3.5	2.0	1
53	PI 430585	P.R. China	2.6	1.5	3.5	2.0	1
54	PI 606019	India	2.6	1.1	3.0	2.0	1
55	PI 618933	P.R. China	2.7	2.5	2.7	2.7	0
56	PI 432873	P.R. China	2.7	2.9	3.0	2.3	0
57	PI 432859	P.R. China	2.7	1.5	3.3	2.0	0
58	Ames 20089	Egypt	2.7	2.3	1.7	3.7	0
59	PI 267741	Japan	2.7	2.4	4.0	1.3	0
60	PI 618924	P.R. China	2.7	1.4	3.7	1.7	0
61	PI 212233	Japan	2.8	3.1	3.0	2.7	2
62	PI 432897	P.R. China	2.8	2.8	3.0	2.7	1
63	PI 478365	P.R. China	2.8	1.8	4.0	2.0	1
64	PI 432870	P.R. China	2.8	2.5	1.3	5.0	1
65	PI 605995	India	2.8	1.5	3.3	2.0	1
66	PI 618911	P.R. China	2.8	2.2	4.3	0.5	1
67	PI 606035	India	2.8	1.1	3.3	2.0	1
68	PI 606060	India	2.8	2.4	3.0	2.7	0
69	PI 618894	P.R. China	2.8	2.4	2.3	3.3	0
70	PI 618912	P.R. China	2.8	2.5	3.0	2.7	0
71	PI 606051	India	2.8	1.2	3.3	2.3	0
72	PI 432883	P.R. China	2.8	2.8	3.3	2.3	0
73	PI 605930	India	2.8	2.4	2.3	3.3	0
74	PI 618861	P.R. China	2.8	2.8	3.3	2.3	0
75	PI 618922	P.R. China	2.8	2.5	4.7	1.0	0

Appendix Table 1 Continued

76	PI 418964	P.R. China	2.8	1.5	3.7	2.0	0
77	PI 432879	P.R. China	2.8	3.3	2.7	3.0	0
78	PI 561145	United States	2.8	3.2	2.3	3.3	0
79	PI 432862	P.R. China	2.8	2.0	4.3	1.3	0
80	PI 419214	Hong Kong	2.8	1.0	3.3	2.3	0
81	PI 227208	Japan	2.8	3.4	2.7	3.0	0
82	M 21	NC State Univ.	3.0	2.1	1.7	4.3	0
83	Calypso	NC State Univ.	3.0	2.5	2.5	3.3	1
84	Ames 26084	United States	3.0	2.3	2.7	3.3	0
85	PI 606048	India	3.0	2.3	2.7	3.3	0
86	PI 374694	Japan	3.0	2.4	3.3	2.7	0
87	Slice	Clemson Univ.	3.0	1.1	3.7	2.3	0
88	Ames 4759	United States	3.0	2.4	3.3	2.7	0
89	PI 618899	P.R. China	3.0	2.4	3.3	2.7	0
90	PI 451975	Canada	3.0	2.4	3.3	2.7	0
91	PI 390268	Japan	3.0	3.3	3.0	3.0	0
92	PI 618863	P.R. China	3.0	2.4	3.3	2.7	0
93	PI 618906	P.R. China	3.0	2.4	3.3	2.7	0
94	LJ 90430	USDA, La Jolla	3.0	4.1	2.0	3.3	3
95	PI 618918	P.R. China	3.0	2.5	4.7	0.5	1
96	PI 618896	P.R. China	3.0	3.2	2.7	3.3	0
97	PI 518851	P.R. China	3.2	2.5	3.7	2.7	0
98	PI 618955	P.R. China	3.2	2.5	3.7	2.7	0
99	PI 390255	Japan	3.2	2.9	4.0	2.3	0
100	PI 511819	Taiwan	3.2	2.6	3.7	2.7	0
101	PI 390258	Japan	3.2	2.2	3.0	3.3	0
102	PI 508460	South Korea	3.2	2.5	3.7	2.7	0
103	PI 618905	P.R. China	3.2	2.2	2.7	3.7	0
104	PI 518850	P.R. China	3.2	2.5	3.7	2.7	0
105	PI 618923	P.R. China	3.2	3.1	3.0	3.3	0
106	PI 618934	P.R. China	3.2	2.6	4.7	1.7	0
107	PI 618907	P.R. China	3.2	2.2	3.0	3.3	0
108	PI 508453	South Korea	3.2	2.2	3.3	3.0	0
109	PI 618919	P.R. China	3.2	2.2	3.3	3.0	0
110	PI 487424	P.R. China	3.2	2.5	3.7	2.7	0
111	PI 504573	India	3.2	1.9	4.3	2.0	0
112	PI 618958	P.R. China	3.2	2.6	3.7	2.7	0
113	PI 227210	Japan	3.2	1.7	4.3	2.0	0
114	PI 432856	P.R. China	3.2	1.2	4.0	2.3	0
115	PI 432891	P.R. China	3.2	3.1	2.3	4.0	0

Appendix Table 1 Continued

116	PI 432853	P.R. China	3.2	1.5	4.0	2.0	1
117	PI 321006	Taiwan	3.2	1.9	4.3	1.5	1
118	Ames 25154	Russian Fed.	3.3	2.6	4.0	2.7	0
119	PI 481614	Bhutan	3.3	2.0	3.0	3.7	0
120	PI 618944	P.R. China	3.3	2.6	4.0	2.7	0
121	PI 432876	P.R. China	3.3	2.9	4.3	2.3	0
122	PI 432858	P.R. China	3.3	2.1	3.0	3.7	0
123	Ames 26085	United States	3.3	2.7	4.0	2.7	0
124	PI 606018	India	3.3	2.6	4.0	2.7	0
125	PI 618874	P.R. China	3.3	2.6	4.0	2.7	0
126	PI 618909	P.R. China	3.3	2.7	4.0	2.7	0
127	PI 432887	P.R. China	3.3	3.1	3.3	3.3	0
128	PI 418989	P.R. China	3.3	1.6	4.3	2.3	0
129	PI 618908	P.R. China	3.3	3.1	3.3	3.3	0
130	PI 436608	P.R. China	3.3	3.0	2.7	4.0	0
131	PI 481616	Bhutan	3.4	2.5	6.0	1.7	1
132	PI 390261	Japan	3.4	1.8	5.0	2.3	1
133	PI 419183	P.R. China	3.4	3.5	3.5	3.3	1
134	PI 504568	India	3.4	2.3	3.0	4.0	1
135	PI 606539	India	3.5	1.8	2.7	4.3	0
136	PI 532523	Japan	3.5	2.7	4.3	2.7	0
137	PI 618867	P.R. China	3.5	2.8	2.0	5.0	0
138	PI 618938	P.R. China	3.5	1.8	2.7	4.3	0
139	Marketmore 76	Cornell Univ.	3.5	2.5	7.0	2.3	2
140	PI 464873	P.R. China	3.5	2.6	4.0	3.0	0
141	PI 606007	India	3.5	2.0	3.3	3.7	0
142	PI 279466	Japan	3.5	2.5	3.0	3.7	2
143	PI 390262	Japan	3.5	2.8	4.0	3.0	0
144	PI 489752	P.R. China	3.5	2.1	3.3	3.7	0
145	PI 390263	Japan	3.5	1.8	2.7	4.3	0
146	Ames 20206	India	3.5	2.0	3.3	3.7	0
147	PI 483339	South Korea	3.5	3.1	3.7	3.3	0
148	PI 321011	Taiwan	3.5	3.2	3.7	3.3	0
149	Ames 7730	United States	3.5	2.3	3.7	3.3	0
150	PI 618872	P.R. China	3.5	3.0	3.0	4.0	0
151	Ames 7753	United States	3.5	2.6	3.0	4.0	2
152	PI 432860	P.R. China	3.5	2.2	5.3	1.7	0
153	PI 279463	Japan	3.5	0.7	4.0	3.0	4
154	PI 618913	P.R. China	3.5	2.6	4.3	2.7	0
155	PI 279467	Japan	3.6	2.6	4.5	3.0	1

Appendix Table 1 Continued

156	PI 163216	Pakistan	3.6	1.7	4.7	2.0	1
157	PI 606020	India	3.6	2.2	4.7	2.0	1
158	PI 605990	India	3.6	2.6	4.5	3.0	1
159	PI 605968	India	3.6	0.9	4.0	3.0	1
160	PI 511818	Taiwan	3.7	1.8	4.3	3.0	0
161	PI 427230	Nepal	3.7	3.5	4.3	3.0	0
162	PI 432884	P.R. China	3.7	2.8	4.0	3.3	0
163	PI 511817	Taiwan	3.7	2.7	4.3	3.0	0
164	PI 432895	P.R. China	3.7	2.7	2.3	5.0	0
165	PI 432894	P.R. China	3.7	2.3	4.0	3.3	0
166	PI 618940	P.R. China	3.7	1.6	3.0	4.3	0
167	PI 419009	P.R. China	3.7	2.7	4.7	2.7	0
168	PI 192940	P.R. China	3.7	2.0	3.7	3.7	0
169	PI 390241	Japan	3.7	2.2	3.7	3.7	0
170	PI 618875	P.R. China	3.7	2.7	4.7	2.7	0
171	PI 302443	Taiwan	3.7	2.1	3.7	3.7	0
172	PI 436672	P.R. China	3.7	2.3	4.0	3.3	0
173	PI 618886	P.R. China	3.7	2.2	5.3	2.0	0
174	Ames 7735	United States	3.7	3.0	3.7	3.7	0
175	PI 482463	Zimbabwe	3.7	2.3	4.3	3.0	0
176	PI 390238	Japan	3.7	2.7	3.0	4.3	0
177	PI 390952	Russian Fed.	3.7	0.8	4.3	3.0	0
178	PI 606044	India	3.7	1.6	3.0	4.3	0
179	PI 618876	P.R. China	3.7	2.0	3.7	3.7	0
180	PI 483340	South Korea	3.7	2.8	3.0	4.3	0
181	PI 390264	Japan	3.7	3.4	4.0	3.3	0
182	PI 432864	Japan	3.7	2.9	3.3	4.0	0
183	PI 618921	P.R. China	3.7	2.3	3.7	3.7	0
184	PI 432871	P.R. China	3.7	2.3	4.0	3.3	0
185	PI 618860	P.R. China	3.7	2.8	3.0	4.3	0
186	PI 432865	Japan	3.7	2.8	3.0	4.3	0
187	PI 183056	India	3.7	2.3	4.3	3.0	0
188	Tablegreen 72	Cornell Univ.	3.7	2.0	3.7	3.7	0
189	PI 605939	India	3.7	2.3	5.0	1.0	3
190	PI 390260	Japan	3.8	2.5	4.0	3.7	2
191	PI 419078	P.R. China	3.8	2.5	3.5	4.0	2
192	PI 214049	India	3.8	3.0	3.0	4.3	1
193	PI 432851	P.R. China	3.8	2.2	4.0	3.7	1
194	PI 605993	India	3.8	2.5	4.0	3.5	1
195	PI 390259	Japan	3.8	3.1	3.0	5.0	1

Appendix Table 1 Continued

196	PI 605992	India	3.8	0.8	4.3	3.0	1
197	PI 114339	Japan	3.8	2.3	4.0	3.7	1
198	PI 605965	India	3.8	2.4	3.7	4.0	1
199	PI 618947	P.R. China	3.8	3.3	3.5	4.0	1
200	PI 390245	Japan	3.8	3.1	3.0	4.3	1
201	PI 606000	India	3.8	2.6	4.5	3.3	1
202	PI 390243	Japan	3.8	2.6	4.0	3.7	0
203	PI 390266	Japan	3.8	2.9	3.0	4.7	0
204	PI 390256	Japan	3.8	3.2	4.3	3.3	0
205	PI 618902	P.R. China	3.8	3.2	4.3	3.3	0
206	PI 618942	P.R. China	3.8	2.3	4.3	3.3	0
207	PI 419017	P.R. China	3.8	1.9	4.0	3.7	0
208	PI 267743	Hong Kong	3.8	2.2	4.0	3.7	0
209	PI 478366	P.R. China	3.8	3.0	5.0	2.7	0
210	Ames 19223	Russian Fed.	3.8	3.0	4.0	3.7	0
211	PI 606041	India	3.8	2.3	4.3	3.3	0
212	PI 432892	P.R. China	4.0	2.8	3.3	4.7	0
213	PI 481617	Bhutan	4.0	1.5	3.7	4.3	0
214	PI 605933	India	4.0	2.5	3.0	5.0	0
215	PI 504564	India	4.0	1.5	3.7	4.3	0
216	PI 482464	Zimbabwe	4.0	2.2	4.0	4.0	1
217	PI 605920	India	4.0	2.8	3.3	4.7	0
218	Dasher II	Seminis	4.0	4.6	3.0	4.5	3
219	PI 105340	P.R. China	4.0	3.7	4.7	3.3	0
220	PI 267935	Japan	4.0	2.0	4.3	3.7	0
221	PI 179676	India	4.0	1.5	3.7	4.3	0
222	PI 605973	India	4.0	2.5	3.0	5.0	0
223	PI 618946	P.R. China	4.0	2.1	4.3	3.7	0
224	PI 605994	India	4.0	2.4	4.7	3.3	0
225	PI 419010	P.R. China	4.0	3.0	4.0	4.0	0
226	PI 606055	India	4.0	1.5	3.7	4.3	0
227	PI 606058	India	4.0	2.4	4.5	3.7	1
228	PI 432868	P.R. China	4.0	2.9	4.0	4.0	0
229	PI 427089	P.R. China	4.0	3.5	4.7	3.3	0
230	PI 179678	India	4.0	1.0	4.7	3.0	1
231	PI 500365	Zambia	4.0	1.5	3.7	4.3	0
232	PI 390269	Japan	4.0	2.4	5.0	3.0	0
233	PI 164173	India	4.0	2.6	4.0	4.0	2
234	Ames 22385	Nepal	4.0	2.5	2.3	5.7	0
235	PI 606006	India	4.0	1.7	3.3	5.0	1

Appendix Table 1 Continued

236	PI 378066	Japan	4.2	2.3	2.7	5.7	0
237	PI 483344	South Korea	4.2	1.5	4.0	4.3	0
238	PI 618943	P.R. China	4.2	2.1	4.7	3.7	0
239	PI 483343	South Korea	4.2	2.4	3.3	5.0	0
240	PI 618953	P.R. China	4.2	2.4	3.3	5.0	0
241	PI 419079	P.R. China	4.2	2.7	4.0	4.3	0
242	PI 489753	P.R. China	4.2	2.6	5.0	3.3	0
243	PI 606028	India	4.2	2.1	4.7	3.7	0
244	PI 255935	Netherlands	4.2	2.1	4.7	3.7	0
245	PI 508454	South Korea	4.2	2.4	4.7	3.7	0
246	PI 618903	P.R. China	4.2	3.3	4.7	3.7	0
247	Ames 19226	Russian Fed.	4.2	2.4	3.3	5.0	0
248	PI 618870	P.R. China	4.2	2.6	4.0	4.3	0
249	PI 605954	India	4.2	2.1	4.7	3.7	0
250	PI 606047	India	4.2	1.5	4.0	4.3	0
251	PI 605919	India	4.2	2.4	3.3	5.0	0
252	PI 358814	Malaysia	4.2	3.1	2.0	6.3	0
253	PI 419041	P.R. China	4.2	2.7	4.0	4.3	0
254	PI 422182	Netherlands	4.2	1.6	3.7	5.0	1
255	PI 279468	Japan	4.2	2.9	3.5	4.7	1
256	PI 606016	India	4.2	1.6	3.7	5.0	1
257	PI 500359	Zambia	4.3	3.0	3.0	5.7	0
258	PI 525075	Mauritius	4.3	2.3	3.7	5.0	0
259	PI 426169	Philippines	4.3	3.3	3.0	5.7	0
260	PI 267745	Brazil	4.3	2.3	5.0	3.7	0
261	Ames 4833	United States	4.3	2.7	3.7	5.0	0
262	PI 419077	P.R. China	4.3	2.7	4.0	4.7	0
263	PI 518852	P.R. China	4.3	1.8	4.3	4.3	0
264	PI 606052	India	4.3	2.2	3.0	5.7	0
265	PI 483342	P.R. China	4.3	2.3	3.7	5.0	0
266	Ames 12781	Nepal	4.3	2.8	4.0	4.7	0
267	PI 605975	India	4.3	1.6	4.3	4.3	0
268	PI 618873	P.R. China	4.3	2.2	5.0	3.7	0
269	PI 462369	India	4.3	2.1	3.0	5.7	0
270	PI 618929	P.R. China	4.3	2.7	3.7	5.0	0
271	PI 435947	Russian Fed.	4.3	2.3	3.7	5.0	0
272	Ames 26918	P.R. China	4.3	2.2	5.0	3.7	0
273	PI 606014	India	4.3	2.7	4.0	4.7	0
274	PI 163222	Pakistan	4.3	2.2	3.0	5.7	0
275	PI 435946	Russian Fed.	4.3	2.2	5.0	3.7	0

Appendix Table 1 Continued

276	PI 606010	India	4.3	2.3	3.7	5.0	0
277	PI 532521	Japan	4.3	2.8	4.3	4.3	0
278	PI 618928	P.R. China	4.3	3.1	3.0	5.7	0
279	PI 432893	P.R. China	4.3	2.9	4.7	4.0	0
280	PI 432855	P.R. China	4.3	2.8	4.3	4.3	0
281	PI 605917	India	4.3	3.2	3.3	5.3	0
282	PI 197087	India	4.3	2.1	5.0	3.7	0
283	PI 164465	India	4.3	1.6	4.3	4.3	0
284	PI 618889	P.R. China	4.3	2.7	4.3	4.3	0
285	PI 606049	India	4.4	2.9	4.0	4.7	1
286	PI 605931	India	4.4	2.6	5.5	3.7	1
287	PI 606005	India	4.4	2.2	4.7	4.0	1
288	PI 618862	P.R. China	4.4	1.7	5.3	3.0	1
289	PI 618936	P.R. China	4.4	2.2	4.7	4.0	1
290	PI 432880	P.R. China	4.5	2.6	4.3	4.7	0
291	PI 532522	Japan	4.5	3.1	3.3	5.7	0
292	PI 531313	Hungary	4.5	2.0	3.3	5.7	0
293	PI 227207	Japan	4.5	2.7	4.3	4.7	0
294	PI 481612	Bhutan	4.5	2.8	4.7	4.3	0
295	PI 263080	Moldova	4.5	2.3	4.0	5.0	0
296	PI 605916	India	4.5	2.0	3.3	5.7	0
297	H-19	Univ. Arkansas	4.5	3.1	3.3	5.7	0
298	PI 390247	Japan	4.5	2.8	2.0	7.0	0
299	PI 432863	Japan	4.5	3.6	2.7	6.3	0
300	PI 390257	Japan	4.5	1.5	4.7	4.3	0
301	PI 605921	India	4.5	2.9	5.0	4.0	0
302	PI 500360	Zambia	4.5	2.0	3.3	5.7	0
303	PI 618957	P.R. China	4.5	2.6	4.3	4.7	0
304	PI 561148	United States	4.5	2.3	4.0	5.0	0
305	PI 508456	South Korea	4.5	2.0	3.3	5.7	0
306	PI 432867	P.R. China	4.5	2.3	4.0	5.0	0
307	PI 605941	India	4.5	3.1	5.3	3.7	0
308	Ames 19224	Russian Fed.	4.5	2.3	4.0	5.0	0
309	PI 224668	South Korea	4.5	3.1	5.0	4.0	0
310	PI 263046	Russian Fed.	4.5	2.3	4.0	5.0	0
311	PI 401732	Puerto Rico	4.5	2.3	4.0	5.0	0
312	PI 436648	P.R. China	4.5	2.2	3.3	5.7	0
313	PI 400270	Japan	4.5	2.9	3.3	5.7	0
314	PI 618954	P.R. China	4.5	2.7	4.7	4.3	0
315	PI 606024	India	4.5	3.1	3.7	5.3	0

Appendix Table 1 Continued

316	PI 605912	India	4.5	2.0	3.3	5.7	0
317	PI 618932	P.R. China	4.5	1.8	4.7	4.3	0
318	PI 164679	India	4.6	2.2	3.0	5.7	1
319	PI 605946	India	4.6	1.5	4.3	5.0	1
320	PI 606057	India	4.6	2.2	3.0	5.7	1
321	Ames 26086	United States	4.7	2.7	3.0	6.3	0
322	PI 432896	P.R. China	4.7	2.7	4.7	4.7	0
323	PI 179921	India	4.7	1.9	3.7	5.7	0
324	PI 206043	Puerto Rico	4.7	2.4	4.3	5.0	0
325	PI 606054	India	4.7	1.9	3.7	5.7	0
326	PI 288238	Japan	4.7	3.4	2.3	7.0	0
327	PI 532161	Oman	4.7	1.6	5.0	4.3	0
328	PI 267197	P.R. China	4.7	2.3	3.7	5.7	0
329	PI 188807	Philippines	4.7	2.7	3.0	6.3	0
330	PI 618939	P.R. China	4.7	2.3	4.3	5.0	0
331	PI 618927	P.R. China	4.7	2.3	4.3	5.0	0
332	PI 432869	P.R. China	4.7	3.1	4.0	5.3	0
333	PI 508459	South Korea	4.7	2.9	3.7	5.7	0
334	PI 390240	Japan	4.7	2.0	5.0	4.3	0
335	PI 606053	India	4.7	1.9	3.7	5.7	0
336	Ames 19222	Russian Fed.	4.7	2.3	4.3	5.0	0
337	PI 390239	Japan	4.7	1.6	5.0	4.3	0
338	PI 618920	P.R. China	4.7	3.4	5.3	4.0	0
339	Ames 7736	United States	4.7	3.4	3.0	6.3	0
340	PI 508457	South Korea	4.7	2.9	3.7	5.7	0
341	PI 605918	India	4.7	2.7	3.0	6.3	0
342	Ames 21761	Bulgaria	4.7	3.7	3.3	6.0	0
343	PI 281448	South Korea	4.7	2.7	5.0	4.3	0
344	PI 605927	India	4.7	2.4	4.3	5.0	0
345	PI 618961	P.R. China	4.7	2.9	3.7	5.7	0
346	PI 466923	Russian Fed.	4.7	2.0	5.0	4.3	0
347	PI 618959	P.R. China	4.7	2.9	3.7	5.7	0
348	PI 504563	Japan	4.7	2.3	4.3	5.0	0
349	PI 606003	India	4.7	1.9	5.0	4.3	0
350	PI 605922	India	4.7	2.7	3.0	6.3	0
351	PI 391571	P.R. China	4.7	2.3	4.3	5.0	0
352	PI 512618	Spain	4.7	2.3	5.7	3.7	0
353	PI 263081	P.R. China	4.7	2.4	5.7	3.7	0
354	PI 500370	Zambia	4.8	2.9	4.0	5.0	2
355	PI 92806	P.R. China	4.8	1.7	4.5	5.0	2

Appendix Table 1 Continued

356	PI 606045	India	4.8	1.5	4.0	7.0	2
357	PI 358813	Malaysia	4.8	3.0	2.7	8.0	1
358	PI 372900	Netherlands	4.8	2.0	3.3	7.0	1
359	PI 436649	P.R. China	4.8	2.8	4.0	6.0	1
360	PI 606066	India	4.8	1.5	4.7	5.0	1
361	PI 261645	India	4.8	3.4	4.0	5.3	1
362	PI 175121	India	4.8	2.4	4.0	6.0	1
363	PI 217644	India	4.8	1.8	4.7	5.0	1
364	PI 279465	Japan	4.8	3.1	4.3	5.3	0
365	PI 518853	P.R. China	4.8	2.4	4.7	5.0	0
366	Ames 12782	Nepal	4.8	2.7	3.3	6.3	0
367	PI 164734	India	4.8	1.8	4.0	5.7	0
368	PI 249562	Thailand	4.8	2.4	2.7	7.0	0
369	PI 606036	India	4.8	1.8	4.0	5.7	0
370	PI 451976	Japan	4.8	2.2	4.7	5.0	0
371	PI 506461	Ukraine	4.8	1.8	4.0	5.7	0
372	PI 606030	India	4.8	2.3	4.7	5.0	0
373	PI 532524	Japan	4.8	3.0	4.0	5.7	0
374	PI 264229	France	4.8	2.6	3.3	6.3	0
375	PI 432890	P.R. China	4.8	3.2	4.3	5.3	0
376	PI 605911	India	4.8	2.6	3.3	6.3	0
377	PI 250147	Pakistan	4.8	2.9	4.0	5.7	0
378	PI 321007	Taiwan	4.8	2.0	4.0	5.7	0
379	PI 618897	P.R. China	4.8	2.2	4.7	5.0	0
380	PI 263084	P.R. China	4.8	2.4	6.0	3.7	0
381	PI 605925	India	4.8	2.0	4.0	5.7	0
382	PI 618901	P.R. China	4.8	2.2	4.7	5.0	0
383	PI 605972	India	4.8	2.6	5.0	4.7	0
384	PI 605983	India	4.8	2.3	4.7	5.0	0
385	Ames 1763	United States	4.8	1.8	4.0	5.7	0
386	PI 164816	India	4.8	2.9	4.0	5.7	0
387	PI 508458	South Korea	4.8	2.4	4.7	5.0	0
388	PI 419135	P.R. China	4.8	1.8	4.0	5.7	0
389	PI 432852	Japan	4.8	3.1	4.0	5.7	0
390	PI 164670	India	4.8	1.8	4.0	5.7	0
391	PI 175120	India	4.8	1.8	4.0	5.7	0
392	PI 606034	India	4.8	2.6	3.3	6.3	0
393	PI 357854	Yugoslavia	5.0	2.8	-	5.0	4
394	PI 470254	Indonesia	5.0	2.2	3.0	7.0	0
395	Ames 3951	Australia	5.0	2.4	5.0	5.0	0

Appendix Table 1 Continued

396	Ames 7749	United States	5.0	3.5	-	5.0	3
397	PI 163213	Pakistan	5.0	2.3	3.0	5.7	2
398	Ames 19039	Kazakhstan	5.0	2.3	5.0	5.0	0
399	PI 606009	India	5.0	1.7	4.3	5.7	0
400	PI 432889	P.R. China	5.0	3.8	4.0	6.0	0
401	PI 512617	Spain	5.0	2.2	5.7	4.3	0
402	Ames 3941	United States	5.0	2.4	5.0	5.0	0
403	PI 289698	Australia	5.0	1.9	4.3	5.7	0
404	PI 390242	Japan	5.0	2.4	3.7	6.3	0
405	PI 227209	Japan	5.0	2.0	4.0	5.7	1
406	PI 618952	P.R. China	5.0	2.3	5.0	5.0	0
407	M 41	NC State Univ.	5.0	5.7	-	5.0	4
408	PI 605997	India	5.0	2.5	3.7	6.3	0
409	PI 605923	India	5.0	2.2	3.0	7.0	0
410	PI 618914	P.R. China	5.0	3.3	3.7	6.3	0
411	PI 605953	India	5.0	2.2	5.0	5.0	0
412	PI 540414	Uzbekistan	5.0	2.8	5.3	4.7	0
413	PI 414159	United States	5.0	1.7	4.3	5.7	0
414	PI 618941	P.R. China	5.0	1.7	4.3	5.7	0
415	PI 267742	Hong Kong	5.0	2.4	5.0	5.0	0
416	PI 175111	India	5.0	1.7	4.3	5.7	0
417	PI 618888	P.R. China	5.0	2.4	5.0	5.0	0
418	PI 618930	P.R. China	5.0	1.7	4.3	5.7	0
419	PI 618885	P.R. China	5.0	2.3	5.0	5.0	0
420	PI 605961	India	5.0	1.6	4.3	7.0	2
421	PI 414158	United States	5.0	2.5	5.7	4.0	1
422	Ames 26916	P.R. China	5.0	2.3	5.7	4.0	1
423	PI 391572	P.R. China	5.0	2.8	4.3	5.7	0
424	PI 432888	P.R. China	5.0	2.8	4.3	5.7	0
425	PI 618891	P.R. China	5.0	2.4	3.7	6.3	0
426	PI 504816	P.R. China	5.0	2.9	5.7	4.3	0
427	PI 344441	Iran	5.0	1.7	4.3	5.7	0
428	PI 263049	Russian Fed.	5.0	1.8	4.3	5.7	0
429	PI 504569	India	5.2	2.1	3.3	7.0	0
430	PI 504562	Russian Fed.	5.2	1.8	6.0	4.3	0
431	PI 263085	P.R. China	5.2	2.3	5.3	5.0	0
432	PI 606022	India	5.2	2.0	3.3	7.0	0
433	PI 605998	India	5.2	2.0	3.3	7.0	0
434	PI 171608	Turkey	5.2	1.6	4.7	5.7	0
435	PI 606001	India	5.2	1.7	4.7	5.7	0

Appendix Table 1 Continued

436	Ames 4421	United States	5.2	2.4	5.3	5.0	0
437	PI 306180	Russian Fed.	5.2	3.1	5.0	5.3	0
438	PI 390265	Japan	5.2	2.8	4.7	5.7	0
439	PI 605964	India	5.2	1.7	4.7	5.7	0
440	PI 512623	Spain	5.2	1.6	4.7	5.7	0
441	PI 436609	P.R. China	5.2	2.7	4.7	5.7	0
442	PI 605977	India	5.2	1.6	4.7	5.7	0
443	PI 606064	India	5.2	2.9	2.7	7.7	0
444	PI 504813	Japan	5.2	2.7	4.7	5.7	0
445	PI 606043	India	5.2	1.7	4.7	5.7	0
446	PI 163218	Pakistan	5.2	1.6	4.7	5.7	0
447	PI 618956	P.R. China	5.2	2.3	5.3	5.0	0
448	PI 606046	India	5.2	2.4	4.0	6.3	0
449	PI 605915	India	5.2	2.0	3.3	7.0	0
450	PI 605949	India	5.2	2.4	5.3	5.0	0
451	PI 606056	India	5.2	2.3	4.0	6.3	0
452	PI 249561	Thailand	5.2	2.4	4.0	6.3	0
453	PI 618951	P.R. China	5.2	3.0	4.7	5.7	0
454	Ames 23007	Czech Republic	5.2	1.7	4.7	5.7	0
455	Ames 3944	United States	5.2	2.3	4.0	6.3	0
456	PI 605976	India	5.2	2.7	4.7	5.7	0
457	PI 163223	Pakistan	5.2	2.0	4.0	7.0	1
458	PI 308915	Russian Fed.	5.2	3.2	4.5	5.7	1
459	PI 288332	India	5.2	2.3	5.3	5.0	1
460	PI 257487	P.R. China	5.2	2.9	5.3	5.0	1
461	PI 222782	Iran	5.2	1.8	5.3	5.0	1
462	PI 511821	Taiwan	5.3	2.6	4.5	6.0	2
463	Ames 7755	United States	5.3	2.1	3.5	7.0	2
464	PI 390244	Japan	5.3	2.1	5.5	5.0	2
465	Ames 7750	United States	5.3	3.3	2.0	6.3	2
466	Sumter	Clemson Univ.	5.3	2.5	3.8	7.0	0
467	PI 483341	South Korea	5.3	1.9	5.0	5.7	0
468	PI 618877	P.R. China	5.3	2.3	4.3	6.3	0
469	PI 173893	India	5.3	1.9	3.7	7.0	0
470	PI 512594	Spain	5.3	1.5	5.0	5.7	0
471	PI 512628	Spain	5.3	1.9	3.7	7.0	0
472	Ames 22384	Nepal	5.3	1.6	5.0	5.7	0
473	PI 390252	Japan	5.3	3.1	4.3	6.3	0
474	PI 618926	P.R. China	5.3	2.3	4.3	6.3	0
475	PI 618879	P.R. China	5.3	2.9	5.0	5.7	0

Appendix Table 1 Continued

476	PI 304803	Japan	5.3	2.3	4.3	6.3	0
477	PI 618904	P.R. China	5.3	2.3	4.3	6.3	0
478	PI 279464	Japan	5.3	2.3	4.3	6.3	0
479	PI 606013	India	5.3	2.3	4.3	6.3	0
480	PI 211984	Iran	5.3	2.9	5.0	5.7	0
481	PI 401733	Puerto Rico	5.3	2.0	3.7	7.0	0
482	PI 618868	P.R. China	5.3	1.6	5.0	5.7	0
483	PI 606011	India	5.3	2.3	4.3	6.3	0
484	Ames 3942	United States	5.3	2.7	5.0	5.7	0
485	PI 605938	India	5.3	2.9	3.7	7.0	0
486	PI 306179	Russian Fed.	5.3	2.7	5.0	5.7	0
487	PI 504571	United States	5.3	2.7	5.0	5.7	0
488	PI 512632	Spain	5.3	1.9	5.0	5.7	0
489	PI 422179	Netherlands	5.3	3.3	4.3	6.3	0
490	PI 422173	Netherlands	5.3	3.2	4.3	6.3	0
491	PI 390249	Japan	5.3	2.3	4.3	6.3	0
492	PI 436673	P.R. China	5.3	2.3	5.7	5.0	0
493	PI 618895	P.R. China	5.3	1.9	5.0	5.7	0
494	PI 489754	P.R. China	5.3	2.7	5.0	5.7	0
495	PI 512598	Spain	5.3	2.4	4.3	6.3	0
496	PI 173892	India	5.4	1.5	4.3	7.0	1
497	PI 618864	P.R. China	5.4	2.5	4.0	6.3	1
498	PI 504572	P.R. China	5.4	2.6	4.0	6.3	1
499	PI 432850	P.R. China	5.4	2.3	5.0	6.0	1
500	PI 605974	India	5.4	1.7	5.7	5.0	1
501	PI 605945	India	5.4	2.5	3.7	8.0	1
502	PI 271328	India	5.5	1.8	4.0	7.0	0
503	PI 271327	India	5.5	2.5	3.3	7.7	0
504	PI 215589	India	5.5	2.5	3.3	7.7	0
505	PI 618900	P.R. China	5.5	2.5	4.7	6.3	0
506	PI 390250	Japan	5.5	2.5	3.3	7.7	0
507	PI 422199	Netherlands	5.5	3.1	4.7	6.3	0
508	PI 606068	India	5.5	1.8	4.0	7.0	0
509	PI 618915	P.R. China	5.5	2.2	4.7	6.3	0
510	PI 200818	Myanmar	5.5	2.0	4.0	7.0	0
511	PI 419136	P.R. China	5.5	3.0	5.3	5.7	0
512	PI 618871	P.R. China	5.5	1.5	5.3	5.7	0
513	PI 606008	India	5.5	2.3	4.7	6.3	0
514	PI 422177	Netherlands	5.5	2.7	3.3	7.7	0
515	PI 271334	India	5.5	2.3	4.7	6.3	0

Appendix Table 1 Continued

516	PI 419182	P.R. China	5.5	2.3	4.7	6.3	0
517	PI 618883	P.R. China	5.5	1.5	5.3	5.7	0
518	PI 173889	India	5.5	1.8	4.0	7.0	0
519	PI 478364	P.R. China	5.5	1.8	5.3	5.7	0
520	PI 605979	India	5.5	1.6	5.3	5.7	0
521	PI 561147	United States	5.5	1.8	4.0	7.0	0
522	PI 308916	Russian Fed.	5.5	2.3	4.7	6.3	0
523	PI 422186	Netherlands	5.5	2.3	4.7	6.3	0
524	PI 606033	India	5.5	2.2	4.7	6.3	0
525	PI 257486	P.R. China	5.5	2.3	4.7	6.3	0
526	PI 512641	Spain	5.5	2.3	4.7	6.3	0
527	PI 175679	Turkey	5.5	2.5	4.7	6.3	0
528	PI 326596	Hungary	5.5	2.8	4.0	7.0	0
529	Ames 19220	Russian Fed.	5.5	2.3	4.7	6.3	0
530	PI 606065	India	5.5	2.8	5.3	5.7	0
531	PI 338235	Turkey	5.5	2.7	5.3	5.7	0
532	PI 321010	Taiwan	5.5	2.0	5.3	5.7	0
533	PI 532519	Russian Fed.	5.5	3.1	3.0	8.0	2
534	PI 422169	Czech Republic	5.6	2.6	5.0	6.0	0
535	PI 512615	Spain	5.6	1.9	3.5	7.0	1
536	PI 606050	India	5.6	1.7	4.7	7.0	1
537	PI 605966	India	5.6	2.2	5.3	6.0	1
538	PI 605942	India	5.6	2.4	4.0	8.0	1
539	PI 504814	P.R. China	5.7	2.7	5.7	5.7	0
540	Straight 8	NSSL	5.7	2.3	3.7	7.7	0
541	PI 500361	Zambia	5.7	1.5	4.3	7.0	0
542	PI 401734	Puerto Rico	5.7	2.3	3.7	7.7	0
543	PI 163217	Pakistan	5.7	1.8	4.3	7.0	0
544	PI 269481	Pakistan	5.7	2.4	3.7	7.7	0
545	PI 422167	Netherlands	5.7	2.4	5.0	6.3	0
546	PI 606023	India	5.7	2.3	3.7	7.7	0
547	Ames 4832	United States	5.7	1.8	5.7	5.7	0
548	PI 368556	Yugoslavia	5.7	1.5	4.3	7.0	0
549	PI 344440	Iran	5.7	2.3	5.0	6.3	0
550	PI 209069	United States	5.7	2.2	5.0	6.3	0
551	PI 370447	Yugoslavia	5.7	1.5	4.3	7.0	0
552	PI 422172	Netherlands	5.7	2.3	3.7	7.7	0
553	PI 183127	India	5.7	1.6	4.3	7.0	0
554	PI 370022	India	5.7	2.2	4.3	7.0	0
555	PI 422200	Czech Republic	5.7	2.4	3.7	7.7	0

Appendix Table 1 Continued

556	PI 606032	India	5.7	3.0	5.0	6.3	0
557	PI 606040	India	5.7	1.5	4.3	7.0	0
558	PI 618917	P.R. China	5.7	2.2	5.0	6.3	0
559	PI 605988	India	5.7	2.3	3.7	7.7	0
560	PI 109483	Turkey	5.7	1.5	4.3	7.0	0
561	PI 618881	P.R. China	5.7	2.2	5.0	6.3	0
562	Ames 26917	P.R. China	5.7	2.7	4.3	7.0	0
563	Ames 19219	Tajikistan	5.7	2.1	5.0	6.3	0
564	Ames 13338	Spain	5.7	2.2	5.0	6.3	0
565	PI 605971	India	5.7	2.2	5.0	6.3	0
566	PI 605936	India	5.7	1.5	4.3	7.0	0
567	PI 344445	Iran	5.7	2.3	5.0	6.3	0
568	PI 618945	P.R. China	5.7	1.8	5.7	5.7	0
569	PI 269480	Pakistan	5.7	3.0	3.0	8.3	0
570	PI 422185	Netherlands	5.7	2.3	3.7	7.7	0
571	PI 220171	Afghanistan	5.7	1.5	5.0	7.0	3
572	PI 605984	India	5.8	2.4	4.7	9.0	2
573	PI 379279	Yugoslavia	5.8	1.9	6.0	5.7	2
574	PI 390248	Japan	5.8	2.7	3.0	7.7	1
575	PI 169401	Turkey	5.8	2.6	5.7	6.0	1
576	PI 605960	India	5.8	1.6	5.0	7.0	1
577	PI 211589	Afghanistan	5.8	1.3	5.0	7.0	1
578	PI 605914	India	5.8	1.6	5.0	7.0	1
579	PI 605967	India	5.8	2.4	4.0	7.7	0
580	Ames 7731	United States	5.8	1.8	6.0	5.7	0
581	PI 605982	India	5.8	2.1	4.0	7.7	0
582	PI 512624	Spain	5.8	1.3	4.7	7.0	0
583	PI 419040	P.R. China	5.8	2.1	5.3	6.3	0
584	PI 605937	India	5.8	2.1	4.0	7.7	0
585	PI 432872	P.R. China	5.8	2.2	5.3	6.3	0
586	Ames 22386	Nepal	5.8	2.2	4.0	7.7	0
587	PI 432857	P.R. China	5.8	2.2	5.3	6.3	0
588	PI 171609	Turkey	5.8	1.3	4.7	7.0	0
589	PI 606012	India	5.8	2.2	4.0	7.7	0
590	PI 368557	Yugoslavia	5.8	1.6	4.7	7.0	0
591	PI 212985	India	5.8	1.3	4.7	7.0	0
592	PI 391568	P.R. China	5.8	1.3	4.7	7.0	0
593	Ames 13247	Spain	5.8	2.4	4.0	7.7	0
594	PI 605991	India	5.8	1.3	4.7	7.0	0
595	PI 326597	Hungary	5.8	2.2	4.0	7.7	0

Appendix Table 1 Continued

596	PI 422218	Israel	5.8	2.9	3.3	8.3	0
597	PI 368555	Yugoslavia	5.8	1.6	4.7	7.0	0
598	Ames 21695	United States	5.8	2.2	4.0	7.7	0
599	PI 376064	Israel	5.8	2.2	4.0	7.7	0
600	PI 605969	India	5.8	2.1	4.0	7.7	0
601	PI 618880	P.R. China	5.8	2.9	6.0	5.7	0
602	PI 478367	P.R. China	5.8	3.0	5.3	6.3	0
603	PI 605951	India	5.8	1.3	4.7	7.0	0
604	Ames 13341	Spain	5.8	2.2	4.0	7.7	0
605	PI 351139	Russian Fed.	5.8	3.4	5.7	6.0	0
606	PI 379284	Yugoslavia	5.8	1.5	4.7	7.0	0
607	PI 605958	India	5.8	2.0	5.3	6.3	0
608	PI 165509	India	5.8	1.3	4.7	7.0	0
609	PI 618949	P.R. China	5.8	2.2	5.3	6.3	0
610	PI 175691	Turkey	5.8	2.2	5.3	6.3	0
611	PI 390253	Japan	5.8	2.4	5.3	6.3	0
612	PI 512644	Spain	5.8	2.4	5.3	6.3	0
613	PI 531310	Hungary	5.8	2.5	4.0	7.7	0
614	PI 504570	India	5.8	2.7	4.0	7.7	0
615	Ames 13336	Spain	5.8	1.5	4.7	7.0	0
616	PI 512607	Spain	5.8	2.1	4.0	7.7	0
617	PI 379280	Yugoslavia	5.8	1.5	4.7	7.0	0
618	PI 618866	P.R. China	6.0	3.3	3.0	9.0	0
619	PI 169384	Turkey	6.0	2.4	3.5	7.7	1
620	PI 605959	India	6.0	2.0	4.7	8.0	1
621	Ames 13356	Spain	6.0	1.5	5.0	7.0	0
622	PI 606004	India	6.0	1.0	5.3	7.0	1
623	PI 512336	Hong Kong	6.0	2.0	5.0	7.0	2
624	Ames 13351	Spain	6.0	1.3	5.0	7.0	0
625	PI 264227	France	6.0	2.0	4.3	7.7	0
626	PI 531308	Hungary	6.0	3.0	5.7	6.3	0
627	Ames 13357	Spain	6.0	1.4	4.5	7.0	1
628	PI 165499	India	6.0	1.4	4.5	7.0	1
629	PI 606067	India	6.0	1.1	5.0	7.0	0
630	PI 271754	Netherlands	6.0	2.2	4.3	7.7	0
631	PI 422180	Netherlands	6.0	2.0	4.7	8.0	1
632	PI 512640	Spain	6.0	1.3	5.0	7.0	0
633	PI 422192	Czech Republic	6.0	1.7	5.0	7.0	0
634	PI 326598	Hungary	6.0	1.3	5.0	7.0	0
635	PI 606002	India	6.0	1.2	5.7	7.0	2

Appendix Table 1 Continued

636	PI 164950	Turkey	6.0	2.0	4.3	7.7	0
637	PI 370019	India	6.0	2.0	4.3	7.7	0
638	Ames 13355	Spain	6.0	2.1	4.3	7.7	0
639	PI 518854	P.R. China	6.0	2.2	5.5	6.3	1
640	PI 263082	P.R. China	6.0	1.5	5.0	7.0	0
641	PI 504815	P.R. China	6.0	2.5	5.0	7.0	0
642	PI 427090	P.R. China	6.0	2.2	4.3	7.7	0
643	PI 432849	P.R. China	6.0	1.7	6.5	5.7	1
644	PI 512601	Spain	6.0	1.3	5.0	7.0	0
645	PI 164284	India	6.0	1.2	5.3	7.0	1
646	PI 512620	Spain	6.0	1.5	5.0	7.0	0
647	PI 532160	Oman	6.0	1.2	5.0	7.0	2
648	PI 605999	India	6.0	2.7	3.7	8.3	0
649	PI 264231	France	6.0	1.7	5.0	7.0	0
650	PI 605913	India	6.0	1.3	5.0	7.0	0
651	PI 605935	India	6.0	2.0	4.3	7.7	0
652	PI 206425	Turkey	6.0	1.3	5.0	7.0	0
653	PI 618878	P.R. China	6.0	2.2	5.5	6.3	1
654	PI 217946	Pakistan	6.0	2.1	4.3	7.7	0
655	PI 391573	P.R. China	6.0	2.4	5.7	6.3	0
656	PI 436610	P.R. China	6.0	2.4	5.7	6.3	0
657	PI 169402	Turkey	6.0	2.7	3.7	8.3	0
658	PI 357834	Yugoslavia	6.0	2.1	5.7	6.3	0
659	PI 267086	Russian Fed.	6.0	2.2	4.3	7.7	0
660	PI 357836	Yugoslavia	6.0	2.0	5.7	6.3	0
661	PI 137844	Iran	6.0	3.0	6.5	5.7	1
662	PI 605955	India	6.0	2.2	4.7	8.0	1
663	PI 176516	Turkey	6.0	2.6	5.0	6.3	2
664	PI 531314	Hungary	6.0	2.6	4.0	8.0	2
665	PI 357857	Yugoslavia	6.0	2.6	5.0	6.3	2
666	PI 355053	Iran	6.0	2.5	5.0	7.0	0
667	PI 379282	Yugoslavia	6.0	2.2	5.7	6.3	0
668	PI 222987	Iran	6.0	2.0	4.7	8.0	1
669	PI 504559	Russian Fed.	6.0	1.4	5.3	7.0	1
670	PI 176924	Turkey	6.0	1.0	5.3	7.0	1
671	PI 344347	Turkey	6.0	1.3	5.0	7.0	0
672	PI 391569	P.R. China	6.0	2.1	4.7	8.0	1
673	PI 357862	Yugoslavia	6.0	2.1	4.7	8.0	1
674	Ames 3943	United States	6.0	2.0	5.7	6.3	0
675	PI 368553	Yugoslavia	6.0	1.3	5.0	7.0	0

Appendix Table 1 Continued

676	PI 169390	Turkey	6.0	3.0	4.5	7.0	1
677	PI 222986	Iran	6.0	1.7	4.5	7.0	1
678	PI 379283	Yugoslavia	6.0	1.3	5.0	7.0	0
679	PI 605944	India	6.2	1.8	4.7	7.7	0
680	PI 512633	Spain	6.2	2.2	4.7	7.7	0
681	PI 512634	Spain	6.2	1.7	5.3	7.0	0
682	PI 255936	Netherlands	6.2	1.8	4.7	7.7	0
683	PI 605986	India	6.2	2.0	6.0	6.3	0
684	PI 606031	India	6.2	1.8	4.7	7.7	0
685	Ames 3947	Canada	6.2	2.2	4.7	7.7	0
686	PI 262990	Netherlands	6.2	1.9	4.7	7.7	0
687	PI 605950	India	6.2	2.6	4.0	8.3	0
688	PI 618884	P.R. China	6.2	1.3	5.3	7.0	0
689	PI 605956	India	6.2	1.8	4.7	7.7	0
690	Ames 13339	Spain	6.2	2.0	4.7	7.7	0
691	PI 422191	Netherlands	6.2	1.9	4.7	7.7	0
692	PI 169391	Turkey	6.2	1.8	4.7	7.7	0
693	PI 422181	Czech Republiclic	6.2	1.6	5.3	7.0	0
694	Ames 13358	Spain	6.2	1.0	5.3	7.0	0
695	PI 466921	Russian Fed.	6.2	2.7	5.3	7.0	0
696	PI 264667	Germany	6.2	2.0	4.7	7.7	0
697	PI 163221	Pakistan	6.2	2.0	4.7	7.7	0
698	PI 174160	Turkey	6.2	2.6	6.0	6.3	0
699	PI 512609	Spain	6.2	2.0	4.7	7.7	0
700	PI 271326	India	6.2	1.9	4.7	7.7	0
701	Ames 7741	United States	6.2	1.8	4.7	7.7	0
702	PI 512638	Spain	6.2	2.2	4.7	7.7	0
703	PI 422176	Netherlands	6.2	1.8	4.7	7.7	0
704	PI 606026	India	6.2	1.9	4.7	7.7	0
705	PI 288990	Hungary	6.2	1.8	4.7	7.7	0
706	PI 220860	South Korea	6.2	1.9	4.7	7.7	0
707	PI 379281	Yugoslavia	6.2	1.2	5.3	7.0	0
708	PI 206952	Turkey	6.2	2.7	4.0	8.3	0
709	PI 379287	Yugoslavia	6.2	1.9	4.7	7.7	0
710	PI 432866	P.R. China	6.2	1.9	4.7	7.7	0
711	Ames 21698	Puerto Rico	6.2	2.0	4.7	7.7	0
712	Ames 13257	Spain	6.2	2.3	6.0	6.3	0
713	PI 283901	Czech Republic	6.2	2.5	4.0	8.3	0
714	PI 512613	Spain	6.2	1.6	5.3	7.0	0
715	Ames 13354	Spain	6.2	2.0	6.0	6.3	0

Appendix Table 1 Continued

716	PI 618898	P.R. China	6.2	2.3	6.0	6.3	0
717	PI 369717	Poland	6.2	2.0	6.0	6.3	0
718	PI 172844	Turkey	6.2	1.3	5.3	7.0	0
719	PI 512604	Spain	6.2	1.8	4.7	7.7	0
720	Ames 7742	United States	6.2	2.5	5.3	7.0	0
721	PI 344348	Turkey	6.2	2.6	4.0	8.3	0
722	PI 227013	Iran	6.2	1.9	4.7	7.7	0
723	PI 512608	Spain	6.2	1.9	4.7	7.7	0
724	Ames 23612	France	6.2	1.8	4.7	7.7	0
725	Ames 25929	Poland	6.2	1.9	4.7	7.7	0
726	PI 202801	Syria	6.2	1.8	4.7	7.7	0
727	PI 605952	India	6.2	2.2	6.0	6.3	1
728	PI 605926	India	6.2	1.3	5.0	7.0	1
729	PI 267746	India	6.2	2.7	4.3	9.0	1
730	PI 606042	India	6.2	2.3	6.0	6.3	1
731	PI 422190	Netherlands	6.2	2.2	6.0	6.3	1
732	PI 512637	Spain	6.2	2.3	4.0	7.7	1
733	PI 606038	India	6.2	2.3	4.0	7.7	1
734	PI 368558	Yugoslavia	6.2	2.8	5.0	7.0	1
735	PI 605989	India	6.2	2.2	4.0	7.7	1
736	Ames 13347	Spain	6.2	2.8	4.3	9.0	1
737	PI 255938	Netherlands	6.2	1.3	5.7	7.0	1
738	PI 605943	India	6.2	1.9	5.0	8.0	1
739	PI 174164	Turkey	6.2	2.3	4.0	7.7	1
740	PI 283900	Czech Republic	6.2	1.1	5.0	7.0	1
741	PI 512642	Spain	6.3	1.5	6.0	7.0	2
742	PI 175688	Turkey	6.3	1.5	4.0	7.0	2
743	PI 422184	Czech Republic	6.3	1.5	5.7	7.0	0
744	Ames 25933	Poland	6.3	2.0	5.0	7.7	0
745	PI 164819	India	6.3	1.6	5.0	7.7	0
746	PI 512619	Spain	6.3	0.8	5.7	7.0	0
747	PI 275410	Netherlands	6.3	2.1	5.0	7.7	0
748	Ames 13345	Spain	6.3	1.2	5.7	7.0	0
749	PI 618925	P.R. China	6.3	1.8	5.0	7.7	0
750	PI 171604	Turkey	6.3	1.2	5.7	7.0	0
751	PI 222243	Iran	6.3	2.9	6.3	6.3	0
752	PI 422196	Netherlands	6.3	0.8	5.7	7.0	0
753	PI 137836	Iran	6.3	2.0	5.0	7.7	0
754	Ames 3946	United States	6.3	1.2	5.7	7.0	0
755	PI 314426	Georgia	6.3	1.2	5.7	7.0	0

Appendix Table 1 Continued

756	Ames 19228	Moldova	6.3	2.4	4.3	8.3	0
757	PI 368552	Yugoslavia	6.3	1.8	5.0	7.7	0
758	PI 261609	Spain	6.3	1.8	5.0	7.7	0
759	PI 605957	India	6.3	2.3	5.7	7.0	0
760	PI 512635	Spain	6.3	1.8	5.0	7.7	0
761	PI 618916	P.R. China	6.3	2.7	5.7	7.0	0
762	PI 176957	Turkey	6.3	1.8	5.0	7.7	0
763	PI 183445	India	6.3	2.0	5.0	7.7	0
764	PI 344353	Turkey	6.3	2.3	4.3	8.3	0
765	PI 406473	Netherlands	6.3	1.8	5.0	7.7	0
766	PI 264666	Germany	6.3	1.8	5.0	7.7	0
767	Ames 13349	Spain	6.3	1.2	5.7	7.0	0
768	PI 466922	Russian Fed.	6.3	2.5	4.3	8.3	0
769	PI 532520	Russian Fed.	6.3	1.8	5.0	7.7	0
770	PI 226510	Iran	6.3	1.8	5.0	7.7	0
771	PI 206954	Turkey	6.3	1.8	5.0	7.7	0
772	PI 179259	Turkey	6.3	1.6	5.7	7.0	0
773	Wis. SMR 18	Wisconsin AES	6.3	1.8	5.0	7.7	0
774	PI 357849	Yugoslavia	6.3	1.6	5.7	7.0	0
775	PI 605981	India	6.3	2.0	5.0	7.7	0
776	PI 229808	Canada	6.3	1.8	5.0	7.7	0
777	PI 357853	Yugoslavia	6.3	1.6	5.0	7.7	0
778	Ames 3948	Canada	6.3	2.0	5.0	7.7	0
779	PI 285610	Poland	6.3	2.0	5.0	7.7	0
780	Ames 7745	United States	6.3	2.0	5.0	7.7	0
781	PI 135123	New Zealand	6.3	1.8	5.0	7.7	0
782	PI 206955	Turkey	6.3	2.1	5.0	7.7	0
783	PI 512616	Spain	6.3	1.8	5.0	7.7	0
784	PI 165506	India	6.3	1.8	5.0	7.7	0
785	PI 264664	Germany	6.3	2.1	5.0	7.7	0
786	PI 507875	Hungary	6.3	2.1	6.3	6.3	0
787	PI 372905	Netherlands	6.3	1.8	5.0	7.7	0
788	PI 351140	Russian Fed.	6.3	1.8	5.0	7.7	0
789	PI 357837	Yugoslavia	6.3	1.8	5.0	7.7	0
790	PI 167223	Turkey	6.3	2.4	4.3	8.3	0
791	PI 222720	Iran	6.3	1.8	5.0	7.7	0
792	PI 264228	France	6.3	1.8	5.0	7.7	0
793	PI 167198	Turkey	6.3	1.8	5.0	7.7	0
794	PI 205996	Sweden	6.3	1.0	5.7	7.0	0
795	PI 357859	Yugoslavia	6.3	1.8	5.0	7.7	0

Appendix Table 1 Continued

796	PI 357852	Yugoslavia	6.3	2.0	5.0	7.7	0
797	PI 368560	Yugoslavia	6.3	1.2	5.7	7.0	0
798	PI 606039	India	6.4	2.8	3.5	8.3	1
799	PI 209065	United States	6.4	2.2	4.5	7.7	1
800	PI 606027	India	6.4	2.2	4.5	7.7	1
801	PI 512631	Spain	6.4	1.9	4.5	7.7	1
802	PI 171611	Turkey	6.4	1.8	5.3	8.0	1
803	PI 344438	Iran	6.4	0.9	5.5	7.0	1
804	PI 223841	Philippines	6.4	1.9	4.5	7.7	1
805	PI 357841	Yugoslavia	6.4	2.2	4.5	7.7	1
806	PI 432848	P.R. China	6.5	2.0	5.3	7.7	0
807	PI 163214	Pakistan	6.5	2.2	4.7	8.3	0
808	Ames 13334	Spain	6.5	1.2	6.0	7.0	0
809	PI 518848	P.R. China	6.5	1.8	5.3	7.7	0
810	PI 178888	Turkey	6.5	1.2	6.0	7.0	0
811	PI 419108	P.R. China	6.5	2.3	4.7	8.3	0
812	PI 531309	Hungary	6.5	2.5	4.7	8.3	0
813	PI 373918	United Kingdom	6.5	0.8	6.0	7.0	0
814	PI 605947	India	6.5	1.4	6.0	7.0	0
815	PI 531312	Hungary	6.5	2.2	4.7	8.3	0
816	PI 103049	P.R. China	6.5	0.8	6.0	7.0	0
817	PI 261608	Spain	6.5	0.8	6.0	7.0	0
818	PI 171603	Turkey	6.5	2.2	4.7	8.3	0
819	Ames 25932	Poland	6.5	1.8	5.3	7.7	0
820	PI 171610	Turkey	6.5	1.0	5.0	7.0	2
821	PI 165046	Turkey	6.5	1.2	6.0	7.0	0
822	PI 169315	Turkey	6.5	2.3	4.7	8.3	0
823	Ames 7740	United States	6.5	1.8	5.3	7.7	0
824	Ames 25938	Poland	6.5	1.6	5.3	7.7	0
825	PI 172843	Turkey	6.5	1.5	5.3	7.7	0
826	Ames 3945	United States	6.5	1.8	5.3	7.7	0
827	PI 422188	Netherlands	6.5	1.5	5.3	7.7	0
828	PI 339241	Turkey	6.5	1.5	5.3	7.7	0
829	PI 512605	Spain	6.5	2.3	4.7	8.3	0
830	Ames 25156	Russian Fed.	6.5	2.3	6.0	7.0	0
831	PI 296120	Egypt	6.5	1.6	5.3	7.7	0
832	PI 605978	India	6.5	1.5	5.3	7.7	0
833	PI 368548	Yugoslavia	6.5	1.6	5.3	7.7	0
834	PI 502331	Uzbekistan	6.5	1.8	5.3	7.7	0
835	PI 118279	Brazil	6.5	1.6	5.3	7.7	0

Appendix Table 1 Continued

836	PI 422197	Czech Republic	6.5	2.7	4.0	9.0	0
837	PI 211985	Iran	6.5	1.6	5.3	7.7	0
838	PI 561146	United States	6.5	1.8	5.3	7.7	0
839	PI 357844	Yugoslavia	6.5	2.3	4.7	8.3	0
840	PI 605963	India	6.5	1.6	5.3	7.7	0
841	PI 175681	Turkey	6.5	1.8	5.3	7.7	0
842	PI 211980	Iran	6.5	2.2	4.7	8.3	0
843	PI 271337	India	6.5	1.5	5.3	7.7	0
844	PI 357851	Yugoslavia	6.5	1.8	5.3	7.7	0
845	PI 339244	Turkey	6.5	2.2	4.7	8.3	0
846	PI 285606	Poland	6.5	0.8	6.0	7.0	0
847	PI 326595	Hungary	6.5	1.2	6.0	7.0	0
848	PI 339245	Turkey	6.5	1.5	5.3	7.7	0
849	PI 422174	Netherlands	6.5	2.8	4.0	9.0	0
850	Ames 13348	Spain	6.5	2.2	4.7	8.3	0
851	PI 342951	Denmark	6.5	2.3	4.7	8.3	0
852	PI 370450	Yugoslavia	6.5	2.3	4.7	8.3	0
853	Ames 25155	Russian Fed.	6.5	1.8	5.3	7.7	0
854	PI 178884	Turkey	6.5	2.2	4.7	8.3	0
855	PI 344437	Iran	6.5	2.2	4.7	8.3	0
856	PI 357850	Yugoslavia	6.5	2.2	4.7	8.3	0
857	Ames 13346	Spain	6.5	1.5	5.3	7.7	0
858	PI 385968	United Kingdom	6.5	2.2	4.7	8.3	0
859	Ames 7785	United States	6.5	1.8	5.3	7.7	0
860	PI 277741	Netherlands	6.5	1.6	5.3	7.7	0
861	PI 264665	Germany	6.5	2.2	4.7	8.3	0
862	PI 357832	Yugoslavia	6.5	1.5	5.3	7.7	0
863	PI 249550	Iran	6.5	2.0	5.3	7.7	0
864	PI 506462	Ukraine	6.5	1.5	5.3	7.7	0
865	PI 251519	Iran	6.5	2.3	4.7	8.3	0
866	Ames 19230	Russian Fed.	6.5	1.6	5.3	7.7	0
867	Ames 25934	Poland	6.5	2.0	6.7	6.3	0
868	PI 512639	Spain	6.5	1.8	5.3	7.7	0
869	PI 167050	Turkey	6.5	2.0	5.3	7.7	0
870	PI 283902	Czech Republic	6.5	2.1	5.0	8.0	2
871	Ames 13342	Spain	6.5	2.0	5.3	7.7	0
872	PI 280096	Ukraine	6.5	1.8	5.3	7.7	0
873	PI 220791	Afghanistan	6.5	1.5	5.3	7.7	0
874	PI 267088	Russian Fed.	6.5	1.6	5.3	7.7	0
875	PI 504565	Russian Fed.	6.5	0.8	6.0	7.0	0

Appendix Table 1 Continued

876	PI 357863	Yugoslavia	6.5	1.5	5.3	7.7	0
877	PI 135122	New Zealand	6.5	1.5	5.3	7.7	0
878	PI 169388	Turkey	6.5	1.6	5.3	7.7	0
879	PI 218036	Iran	6.5	1.5	5.3	7.7	0
880	PI 357830	Yugoslavia	6.5	0.8	6.0	7.0	0
881	PI 271331	India	6.5	0.8	6.0	7.0	0
882	PI 561144	United States	6.6	2.2	5.0	7.7	1
883	PI 221440	Afghanistan	6.6	1.8	5.0	7.7	1
884	PI 176952	Turkey	6.6	1.7	5.0	7.7	1
885	PI 263083	P.R. China	6.6	1.8	5.0	7.7	1
886	PI 206953	Turkey	6.6	1.8	5.0	7.7	1
887	PI 177363	Syria	6.6	1.5	5.7	8.0	1
888	Ames 1760	United States	6.6	1.8	5.0	7.7	1
889	PI 226461	Iran	6.6	2.5	4.0	8.3	1
890	PI 339246	Turkey	6.6	1.5	5.7	8.0	1
891	PI 368559	Yugoslavia	6.6	1.7	5.0	7.7	1
892	PI 288996	Hungary	6.6	1.8	5.0	7.7	1
893	PI 422198	Netherlands	6.6	1.7	5.0	7.7	1
894	PI 379286	Yugoslavia	6.6	1.8	5.0	7.7	1
895	Ames 25930	Poland	6.7	2.1	5.0	8.3	0
896	PI 172849	Turkey	6.7	2.1	5.7	7.7	0
897	Ames 13350	Spain	6.7	1.4	5.7	7.7	0
898	PI 618865	P.R. China	6.7	1.4	5.7	7.7	0
899	PI 372898	Netherlands	6.7	1.4	5.7	7.7	0
900	PI 606021	India	6.7	2.1	5.0	8.3	0
901	PI 540415	Uzbekistan	6.7	2.3	5.7	7.7	0
902	PI 292011	Israel	6.7	1.6	5.7	7.7	0
903	PI 169392	Turkey	6.7	1.9	5.7	7.7	0
904	PI 292012	Israel	6.7	2.1	5.0	8.3	0
905	PI 504567	Russian Fed.	6.7	2.0	5.7	7.7	0
906	PI 275411	Netherlands	6.7	1.6	5.7	7.7	0
907	PI 618910	P.R. China	6.7	1.6	5.7	7.7	0
908	PI 458855	Russian Fed.	6.7	1.5	5.7	7.7	0
909	PI 285604	Poland	6.7	1.6	5.7	7.7	0
910	PI 181942	Syria	6.7	2.3	5.0	8.3	0
911	PI 176950	Turkey	6.7	1.4	5.7	7.7	0
912	PI 357865	Yugoslavia	6.7	1.6	5.7	7.7	0
913	PI 109063	Turkey	6.7	2.1	5.0	8.3	0
914	PI 229309	Iran	6.7	2.1	5.0	8.3	0
915	PI 175686	Turkey	6.7	2.0	5.0	8.3	0

Appendix Table 1 Continued

916	PI 265887	Netherlands	6.7	1.4	5.7	7.7	0
917	PI 169353	Turkey	6.7	2.1	5.0	8.3	0
918	PI 255934	Netherlands	6.7	1.4	5.7	7.7	0
919	PI 372893	Netherlands	6.7	2.3	5.0	8.3	0
920	PI 109482	Turkey	6.7	2.0	5.0	8.3	0
921	PI 357831	Yugoslavia	6.7	1.4	5.7	7.7	0
922	PI 285605	Poland	6.7	1.6	5.7	7.7	0
923	PI 506465	Ukraine	6.7	2.1	5.0	8.3	0
924	PI 525156	Egypt	6.7	2.1	7.0	6.3	0
925	PI 171612	Turkey	6.7	1.6	5.7	7.7	0
926	PI 512636	Spain	6.7	2.1	5.0	8.3	0
927	PI 188749	Egypt	6.7	2.1	5.0	8.3	0
928	PI 169352	Turkey	6.7	1.6	5.7	7.7	0
929	PI 175692	Turkey	6.7	1.4	5.7	7.7	0
930	PI 314425	Georgia	6.7	1.6	5.7	7.7	0
931	PI 357860	Yugoslavia	6.7	1.6	5.7	7.7	0
932	PI 204569	Turkey	6.7	2.1	5.0	8.3	0
933	PI 605962	India	6.7	1.5	5.7	7.7	0
934	PI 376063	Israel	6.7	2.1	5.0	8.3	0
935	PI 169400	Turkey	6.7	1.5	5.7	7.7	0
936	PI 344443	Iran	6.7	2.3	7.0	6.3	0
937	PI 212059	Greece	6.7	1.6	5.7	7.7	0
938	PI 368549	Yugoslavia	6.7	2.1	5.0	8.3	0
939	PI 357856	Yugoslavia	6.7	1.6	5.7	7.7	0
940	PI 169389	Turkey	6.7	1.4	5.7	7.7	0
941	PI 507876	Hungary	6.7	1.6	5.7	7.7	0
942	PI 228344	Iran	6.7	1.4	5.7	7.7	0
943	PI 339248	Turkey	6.7	1.5	5.7	7.7	0
944	PI 164743	India	6.7	2.3	5.0	8.3	0
945	PI 618950	P.R. China	6.7	2.1	5.0	8.3	0
946	PI 251028	Afghanistan	6.7	1.6	5.7	7.7	0
947	PI 293432	Lebanon	6.7	1.6	5.7	7.7	0
948	PI 227235	Iran	6.7	1.4	5.7	7.7	0
949	PI 175680	Turkey	6.8	2.1	5.5	8.0	2
950	Ames 7739	United States	6.8	2.1	4.0	7.7	2
951	PI 512606	Spain	6.8	2.1	4.0	7.7	2
952	PI 357848	Yugoslavia	6.8	1.8	5.5	7.7	1
953	Ames 7737	United States	6.8	1.5	5.5	7.7	1
954	PI 171600	Turkey	6.8	1.5	6.0	8.0	1
955	PI 211986	Iran	6.8	1.5	6.0	8.0	1

Appendix Table 1 Continued

956	PI 205181	Turkey	6.8	2.3	4.5	8.3	1
957	PI 178885	Turkey	6.8	1.3	6.0	7.7	0
958	NSL 209654	United States	6.8	1.3	6.0	7.7	0
959	PI 209066	United States	6.8	2.0	5.3	8.3	0
960	PI 606037	India	6.8	2.0	5.3	8.3	0
961	PI 169319	Turkey	6.8	1.7	6.0	7.7	0
962	PI 504566	Russian Fed.	6.8	1.3	6.0	7.7	0
963	PI 356832	Netherlands	6.8	2.4	5.3	8.3	0
964	PI 357838	Yugoslavia	6.8	1.2	6.0	7.7	0
965	PI 257286	Spain	6.8	1.9	5.3	8.3	0
966	PI 605934	India	6.8	1.9	5.3	8.3	0
967	PI 304805	United States	6.8	1.7	6.0	7.7	0
968	Ames 19221	Ukraine	6.8	2.0	5.3	8.3	0
969	PI 357869	Yugoslavia	6.8	1.9	5.3	8.3	0
970	PI 512599	Spain	6.8	1.9	5.3	8.3	0
971	PI 211728	Afghanistan	6.8	1.8	5.3	8.3	0
972	Ames 19229	Russian Fed.	6.8	1.9	5.3	8.3	0
973	Ames 21694	United States	6.8	1.7	6.0	7.7	0
974	PI 357864	Yugoslavia	6.8	1.6	6.0	7.7	0
975	PI 255937	Netherlands	6.8	2.0	5.3	8.3	0
976	PI 355055	Iran	6.8	1.8	5.3	8.3	0
977	PI 169387	Turkey	6.8	1.2	6.0	7.7	0
978	PI 222244	Iran	6.8	1.6	6.0	7.7	0
979	PI 357861	Yugoslavia	6.8	1.8	5.3	8.3	0
980	PI 193496	Ethiopia	6.8	2.0	5.3	8.3	0
981	PI 326594	Hungary	6.8	1.9	5.3	8.3	0
982	Ames 22250	Albania	6.8	1.7	6.0	7.7	0
983	PI 165029	Turkey	6.8	1.3	6.0	7.7	0
984	PI 344349	Turkey	6.8	1.2	6.0	7.7	0
985	PI 512602	Spain	6.8	1.3	6.0	7.7	0
986	PI 176521	Turkey	6.8	1.2	6.0	7.7	0
987	PI 211982	Iran	6.8	1.9	5.3	8.3	0
988	PI 176956	Turkey	6.8	2.5	4.7	9.0	0
989	PI 357835	Yugoslavia	6.8	1.0	6.7	7.0	0
990	PI 422183	Netherlands	6.8	1.9	5.3	8.3	0
991	PI 182190	Turkey	6.8	1.6	6.0	7.7	0
992	PI 222783	Iran	6.8	2.3	5.3	8.3	0
993	PI 169380	Turkey	6.8	2.0	5.3	8.3	0
994	PI 357840	Yugoslavia	6.8	1.3	6.0	7.7	0
995	PI 183231	Egypt	6.8	1.9	5.3	8.3	0

Appendix Table 1 Continued

996	Ames 25937	Poland	6.8	1.3	6.0	7.7	0
997	PI 227664	Iran	6.8	1.3	6.0	7.7	0
998	PI 525163	Egypt	6.8	1.8	5.3	8.3	0
999	PI 288995	Hungary	6.8	2.6	4.7	9.0	0
1000	PI 458846	Russian Fed.	6.8	2.3	5.3	8.3	0
1001	PI 458853	Russian Fed.	6.8	1.3	6.0	7.7	0
1002	PI 274902	United Kingdom	6.8	2.0	5.3	8.3	0
1003	PI 293923	Israel	6.8	1.9	5.3	8.3	0
1004	PI 357846	Yugoslavia	6.8	2.0	5.3	8.3	0
1005	PI 512627	Spain	6.8	1.9	5.3	8.3	0
1006	PI 490996	Turkey	6.8	1.9	5.3	8.3	0
1007	PI 512610	Spain	6.8	1.3	6.0	7.7	0
1008	PI 222985	Iran	6.8	2.0	5.3	8.3	0
1009	PI 179260	Turkey	6.8	2.5	4.7	9.0	0
1010	PI 211943	Iran	6.8	1.3	6.0	7.7	0
1011	Ames 25935	Poland	6.8	2.0	5.3	8.3	0
1012	PI 137845	Iran	6.8	1.3	6.0	7.7	0
1013	PI 357845	Yugoslavia	6.8	1.6	6.0	7.7	0
1014	PI 211978	Iran	6.8	1.9	5.3	8.3	0
1015	PI 525153	Egypt	6.8	1.3	6.0	7.7	0
1016	PI 263078	Ukraine	6.8	2.0	5.3	8.3	0
1017	PI 422189	Netherlands	6.8	1.6	6.0	7.7	0
1018	PI 458848	Russian Fed.	6.8	1.3	6.0	7.7	0
1019	PI 182192	Turkey	6.8	1.6	6.0	7.7	0
1020	PI 177360	Turkey	6.8	1.3	6.0	7.7	0
1021	PI 357847	Yugoslavia	6.8	1.2	6.0	7.7	0
1022	PI 525154	Egypt	6.8	1.3	6.0	7.7	0
1023	PI 169377	Turkey	6.8	1.9	5.3	8.3	0
1024	PI 370448	Yugoslavia	6.8	1.3	6.0	7.7	0
1025	PI 169399	Turkey	6.8	1.2	6.0	7.7	0
1026	Ames 7758	United States	7.0	-	-	7.0	5
1027	PI 279469	Japan	7.0	0.0	-	7.0	4
1028	PI 338234	Turkey	7.0	0.0	-	7.0	4
1029	PI 306785	Canada	7.0	0.0	7.0	7.0	2
1030	PI 512614	Spain	7.0	1.2	6.0	7.7	1
1031	PI 422168	Czech Republiclic	7.0	1.9	5.7	8.3	0
1032	PI 288991	Hungary	7.0	1.9	5.7	8.3	0
1033	PI 458852	Russian Fed.	7.0	1.3	6.3	7.7	0
1034	PI 506464	Russian Fed.	7.0	1.1	6.3	7.7	0
1035	PI 512603	Spain	7.0	1.7	5.7	8.3	0

Appendix Table 1 Continued

1036	Ames 19231	Russian Fed.	7.0	1.9	5.7	8.3	0
1037	PI 422171	Netherlands	7.0	1.9	5.7	8.3	0
1038	PI 211988	Iran	7.0	1.8	6.3	7.7	0
1039	PI 512626	Spain	7.0	1.9	5.7	8.3	0
1040	Ames 7744	United States	7.0	1.9	5.7	8.3	0
1041	Ames 7738	United States	7.0	1.9	5.7	8.3	0
1042	PI 390951	Georgia	7.0	1.7	5.7	8.3	0
1043	Ames 19038	Kazakhstan	7.0	1.7	5.7	8.3	0
1044	PI 343452	Russian Fed.	7.0	1.9	5.7	8.3	0
1045	PI 344442	Iran	7.0	1.9	5.7	8.3	0
1046	Ames 21696	United States	7.0	1.9	5.7	8.3	0
1047	PI 169395	Turkey	7.0	1.7	5.7	8.3	0
1048	PI 137839	Iran	7.0	1.9	5.7	8.3	0
1049	PI 534541	Syria	7.0	1.9	5.7	8.3	0
1050	PI 169381	Turkey	7.0	1.2	6.0	7.7	1
1051	PI 512600	Spain	7.0	1.7	5.7	8.3	0
1052	PI 209068	United States	7.0	1.9	5.7	8.3	0
1053	PI 174166	Turkey	7.0	2.3	5.0	9.0	0
1054	PI 172851	Turkey	7.0	1.8	5.7	8.3	0
1055	PI 606029	India	7.0	1.4	6.3	7.7	0
1056	Ames 13352	Spain	7.0	1.3	6.3	7.7	0
1057	PI 275412	Netherlands	7.0	1.1	6.3	7.7	0
1058	PI 175693	Turkey	7.0	2.3	5.0	9.0	0
1059	PI 525161	Egypt	7.0	1.9	5.7	8.3	0
1060	Ames 23008	Czech Republic	7.0	1.9	5.7	8.3	0
1061	PI 512625	Spain	7.0	1.1	6.3	7.7	0
1062	PI 605940	India	7.0	2.3	5.0	9.0	0
1063	PI 169393	Turkey	7.0	2.3	5.7	8.3	0
1064	PI 137853	Iran	7.0	2.3	5.0	9.0	0
1065	PI 220790	Afghanistan	7.0	1.8	5.7	8.3	0
1066	PI 178887	Turkey	7.0	1.3	6.3	7.7	0
1067	PI 176525	Turkey	7.0	2.3	5.0	9.0	0
1068	PI 167079	Turkey	7.0	2.3	5.0	9.0	0
1069	PI 263048	Uzbekistan	7.0	2.0	5.0	8.3	1
1070	PI 512597	Spain	7.0	1.9	5.7	8.3	0
1071	PI 169403	Turkey	7.0	1.8	5.7	8.3	0
1072	PI 176524	Turkey	7.0	1.9	5.7	8.3	0
1073	PI 379278	Yugoslavia	7.0	1.9	5.7	8.3	0
1074	PI 458850	Russian Fed.	7.0	1.9	5.7	8.3	0
1075	PI 344444	Iran	7.0	1.8	5.7	8.3	0

Appendix Table 1 Continued

1076	PI 512595	Spain	7.0	1.9	5.7	8.3	0
1077	PI 271753	Belgium	7.0	2.3	5.0	9.0	0
1078	PI 164951	Turkey	7.0	1.9	5.7	8.3	0
1079	PI 344439	Iran	7.0	1.9	5.7	8.3	0
1080	PI 540416	Uzbekistan	7.0	2.1	5.7	9.0	1
1081	PI 344432	Iran	7.0	1.9	5.7	8.3	0
1082	PI 174174	Turkey	7.0	1.9	5.7	8.3	0
1083	PI 357866	Yugoslavia	7.0	1.8	5.7	8.3	0
1084	PI 207476	Afghanistan	7.0	1.7	5.7	8.3	0
1085	PI 370449	Yugoslavia	7.0	1.7	5.7	8.3	0
1086	PI 458854	Russian Fed.	7.0	1.7	5.7	8.3	0
1087	PI 283899	Czech Republiclic	7.0	1.9	5.7	8.3	0
1088	PI 339247	Turkey	7.0	1.9	5.7	8.3	0
1089	Ames 19218	Russian Fed.	7.0	1.7	5.7	8.3	0
1090	PI 390953	Uzbekistan	7.0	1.9	5.7	8.3	0
1091	PI 176519	Turkey	7.0	2.0	5.0	8.3	1
1092	PI 172839	Turkey	7.0	2.0	5.0	8.3	1
1093	PI 357843	Yugoslavia	7.0	2.0	5.0	8.0	3
1094	Coolgreen	Seminis	7.0	1.7	5.7	8.3	0
1095	PI 209067	United States	7.0	1.7	5.7	8.3	0
1096	PI 171607	Turkey	7.0	1.7	5.7	8.3	0
1097	PI 535880	Poland	7.0	1.4	6.3	7.7	0
1098	PI 169351	Turkey	7.0	1.3	6.3	7.7	0
1099	PI 525159	Egypt	7.0	1.1	6.3	7.7	0
1100	PI 181755	Lebanon	7.0	1.7	5.7	8.3	0
1101	PI 233932	Canada	7.0	1.9	5.7	8.3	0
1102	PI 344352	Turkey	7.0	2.3	5.0	9.0	0
1103	PI 171602	Turkey	7.0	1.9	6.0	7.7	1
1104	PI 354952	Denmark	7.0	1.3	6.3	7.7	0
1105	PI 169350	Turkey	7.0	1.1	6.3	7.7	0
1106	PI 285609	Poland	7.0	1.1	6.3	7.7	0
1107	PI 269482	Pakistan	7.0	1.3	6.3	7.7	0
1108	PI 211979	Iran	7.0	1.1	6.3	7.7	0
1109	PI 137835	Iran	7.0	1.1	6.3	7.7	0
1110	PI 618882	P.R. China	7.2	1.6	6.0	8.3	0
1111	PI 182189	Turkey	7.2	1.6	6.0	8.3	0
1112	PI 175697	Turkey	7.2	1.5	6.0	8.3	0
1113	PI 357868	Yugoslavia	7.2	1.6	6.0	8.3	0
1114	PI 171605	Turkey	7.2	1.8	6.7	7.7	0
1115	PI 605970	India	7.2	1.6	6.0	8.3	0

Appendix Table 1 Continued

1116	PI 135345	Afghanistan	7.2	1.5	6.0	8.3	0
1117	PI 355052	Israel	7.2	1.6	6.0	8.3	0
1118	PI 204692	Turkey	7.2	1.8	6.0	8.3	0
1119	PI 181753	Syria	7.2	1.9	6.0	8.3	0
1120	PI 267747	United States	7.2	1.6	6.0	8.3	0
1121	PI 525165	Egypt	7.2	1.6	6.0	8.3	0
1122	PI 172841	Turkey	7.2	1.6	6.0	8.3	0
1123	PI 251520	Iran	7.2	1.6	6.0	8.3	0
1124	PI 137857	Iran	7.2	1.8	6.0	8.3	0
1125	PI 172845	Turkey	7.2	1.8	6.0	8.3	0
1126	PI 344067	Turkey	7.2	1.5	6.0	8.3	0
1127	PI 432861	P.R. China	7.2	1.6	6.0	8.3	0
1128	PI 211962	Iran	7.2	2.5	5.3	9.0	0
1129	Ames 13353	Spain	7.2	1.8	6.7	7.7	0
1130	PI 211967	Iran	7.2	1.6	6.0	8.3	0
1131	PI 506463	Russian Fed.	7.2	1.6	6.0	8.3	0
1132	PI 211117	Israel	7.2	1.6	6.0	8.3	0
1133	PI 264668	Germany	7.2	2.1	5.3	9.0	0
1134	PI 264226	France	7.2	2.4	5.3	9.0	0
1135	PI 422170	Netherlands	7.2	1.8	6.0	8.3	0
1136	PI 458847	Russian Fed.	7.2	1.9	6.0	8.3	0
1137	PI 171606	Turkey	7.2	2.2	5.3	9.0	0
1138	PI 167134	Turkey	7.2	2.2	5.3	9.0	0
1139	PI 525152	Egypt	7.2	2.2	5.3	9.0	0
1140	PI 324239	Sweden	7.2	2.4	5.3	9.0	0
1141	PI 220338	Afghanistan	7.2	2.0	5.3	9.0	0
1142	PI 525155	Egypt	7.2	1.8	6.0	8.3	0
1143	PI 248778	Iran	7.2	2.4	5.3	9.0	0
1144	PI 288993	Hungary	7.2	2.1	5.3	9.0	0
1145	PI 319216	Egypt	7.2	1.6	6.0	8.3	0
1146	PI 368554	Yugoslavia	7.2	1.6	6.0	8.3	0
1147	PI 175696	Turkey	7.2	2.2	5.3	9.0	0
1148	PI 181910	Syria	7.2	1.6	6.0	8.3	0
1149	PI 357833	Yugoslavia	7.2	1.6	6.0	8.3	0
1150	PI 137847	Iran	7.2	1.8	6.0	8.3	0
1151	PI 357858	Yugoslavia	7.2	1.8	6.0	8.3	0
1152	PI 174177	Turkey	7.2	1.8	6.0	8.3	0
1153	PI 357867	Yugoslavia	7.2	1.8	6.0	8.3	0
1154	PI 178886	Turkey	7.2	1.6	6.0	8.3	0
1155	PI 535881	Poland	7.2	1.5	6.0	8.3	0

Appendix Table 1 Continued

1156	PI 169397	Turkey	7.2	2.4	5.3	9.0	0
1157	PI 174170	Turkey	7.2	1.6	6.0	8.3	0
1158	PI 360939	Netherlands	7.2	1.8	6.0	8.3	0
1159	PI 183677	Turkey	7.2	2.2	5.3	9.0	0
1160	PI 220169	Afghanistan	7.2	1.6	6.0	8.3	0
1161	PI 193497	Ethiopia	7.2	1.8	6.0	8.3	0
1162	PI 169386	Turkey	7.2	1.6	6.0	8.3	0
1163	PI 169334	Turkey	7.2	1.6	6.0	8.3	0
1164	PI 209064	United States	7.2	1.5	6.0	8.3	0
1165	PI 172847	Turkey	7.2	1.5	6.0	8.3	0
1166	PI 173674	Turkey	7.2	1.6	6.0	8.3	0
1167	PI 292010	Israel	7.2	1.6	6.0	8.3	0
1168	PI 176517	Turkey	7.2	1.6	6.0	8.3	0
1169	Ames 19227	Russian Fed.	7.2	1.8	5.5	8.3	1
1170	PI 137856	Iran	7.2	1.8	5.5	8.3	1
1171	PI 296121	Egypt	7.2	2.5	4.5	9.0	1
1172	PI 458849	Russian Fed.	7.2	2.0	6.0	9.0	1
1173	PI 296387	Iran	7.2	1.8	5.5	8.3	1
1174	PI 211977	Iran	7.2	2.0	5.5	8.3	1
1175	PI 223437	Afghanistan	7.2	2.0	5.5	8.3	1
1176	PI 357842	Yugoslavia	7.2	2.0	5.5	8.3	1
1177	PI 507874	Hungary	7.2	1.8	5.5	8.3	1
1178	PI 344433	Iran	7.2	2.0	5.5	8.3	1
1179	PI 534539	Syria	7.2	1.8	5.5	8.3	1
1180	PI 339250	Turkey	7.2	2.0	5.5	8.3	1
1181	PI 181756	Lebanon	7.3	2.1	5.7	9.0	0
1182	Ames 7751	United States	7.3	1.5	6.0	8.0	3
1183	PI 344351	Turkey	7.3	1.5	6.3	8.3	0
1184	Ames 25931	Poland	7.3	1.4	6.3	8.3	0
1185	Ames 13335	Spain	7.3	2.1	6.3	8.3	0
1186	PI 414157	United States	7.3	1.5	6.3	8.3	0
1187	PI 379285	Macedonia	7.3	1.5	6.3	8.3	0
1188	PI 176953	Turkey	7.3	2.1	6.3	8.3	0
1189	PI 525150	Egypt	7.3	1.4	6.3	8.3	0
1190	PI 167197	Turkey	7.3	1.4	6.3	8.3	0
1191	PI 175689	Turkey	7.3	1.5	6.3	8.3	0
1192	PI 205995	Sweden	7.3	1.5	6.3	8.3	0
1193	PI 174167	Turkey	7.3	2.1	5.7	9.0	0
1194	PI 176520	Turkey	7.3	1.5	6.3	8.3	0
1195	PI 344435	Iran	7.3	2.1	5.7	9.0	0

Appendix Table 1 Continued

1196	PI 175690	Turkey	7.3	1.9	5.7	9.0	0
1197	Ames 25936	Poland	7.3	2.1	5.7	9.0	0
1198	PI 172838	Turkey	7.3	2.1	5.7	9.0	0
1199	PI 175683	Turkey	7.3	2.0	6.3	8.3	0
1200	PI 176518	Turkey	7.3	2.0	5.7	9.0	0
1201	PI 344434	Iran	7.3	2.1	5.7	9.0	0
1202	PI 392292	Russian Fed.	7.3	1.5	6.3	8.3	0
1203	PI 525157	Egypt	7.3	2.1	5.7	9.0	0
1204	PI 169394	Turkey	7.3	1.9	5.7	9.0	0
1205	PI 370643	Russian Fed.	7.3	1.5	6.3	8.3	0
1206	PI 177364	Iraq	7.3	2.0	5.7	9.0	0
1207	PI 357839	Yugoslavia	7.3	1.5	6.3	8.3	0
1208	PI 339243	Turkey	7.3	1.9	5.7	9.0	0
1209	PI 169398	Turkey	7.3	2.1	5.7	9.0	0
1210	PI 512596	Spain	7.3	1.0	7.0	7.7	0
1211	PI 534545	Syria	7.3	1.5	6.3	8.3	0
1212	PI 390954	Russian Fed.	7.3	1.5	6.3	8.3	0
1213	PI 288994	Hungary	7.3	1.4	6.3	8.3	0
1214	PI 534543	Syria	7.3	1.5	6.3	8.3	0
1215	PI 183224	Egypt	7.3	1.4	6.3	8.3	0
1216	PI 211983	Iran	7.3	1.4	6.3	8.3	0
1217	PI 176951	Turkey	7.3	2.0	5.7	9.0	0
1218	PI 368550	Yugoslavia	7.3	1.9	5.7	9.0	0
1219	PI 182188	Turkey	7.3	1.4	6.3	8.3	0
1220	PI 525151	Egypt	7.3	1.4	6.3	8.3	0
1221	Ames 25699	Syria	7.3	1.4	6.3	8.3	0
1222	PI 525162	Egypt	7.3	1.4	6.3	8.3	0
1223	PI 368551	Yugoslavia	7.3	0.8	7.0	7.7	0
1224	PI 458856	Ukraine	7.3	0.8	7.0	7.7	0
1225	Ames 3950	Australia	7.4	1.5	6.0	8.3	1
1226	PI 605980	India	7.4	2.3	6.3	9.0	1
1227	PI 264230	France	7.4	2.6	5.0	9.0	1
1228	PI 172848	Turkey	7.4	1.5	6.0	8.3	1
1229	PI 263047	Russian Fed.	7.4	2.3	5.0	9.0	1
1230	PI 285607	Poland	7.4	1.7	6.0	8.3	1
1231	PI 179263	Turkey	7.4	2.3	5.0	9.0	1
1232	PI 164952	Turkey	7.4	1.7	6.3	9.0	1
1233	PI 218199	Lebanon	7.4	1.7	6.0	8.3	1
1234	PI 263079	Russian Fed.	7.4	1.7	6.0	8.3	1
1235	PI 175695	Turkey	7.4	1.7	6.3	9.0	1

Appendix Table 1 Continued

1236	PI 167358	Turkey	7.5	1.9	5.0	8.3	2
1237	PI 257494	Iran	7.5	2.0	6.0	9.0	0
1238	PI 504561	Russian Fed.	7.5	1.5	6.7	8.3	0
1239	PI 204690	Turkey	7.5	1.8	6.0	9.0	0
1240	PI 458845	Russian Fed.	7.5	1.5	6.7	8.3	0
1241	PI 211975	Iran	7.5	1.8	6.0	9.0	0
1242	PI 169383	Turkey	7.5	1.5	6.7	8.3	0
1243	PI 105263	Turkey	7.5	2.0	6.0	9.0	0
1244	PI 176954	Turkey	7.5	1.8	6.0	9.0	0
1245	PI 174173	Turkey	7.5	1.8	6.0	9.0	0
1246	PI 177359	Turkey	7.5	2.0	6.0	9.0	0
1247	PI 109484	Turkey	7.5	1.8	6.0	9.0	0
1248	PI 204567	Turkey	7.5	1.8	6.0	9.0	0
1249	PI 288992	Hungary	7.5	2.0	6.0	9.0	0
1250	PI 181940	Syria	7.5	1.8	6.0	9.0	0
1251	PI 285603	Poland	7.5	2.0	6.0	9.0	0
1252	PI 356809	Russian Fed.	7.5	2.0	6.0	9.0	0
1253	PI 357855	Yugoslavia	7.5	1.8	6.0	9.0	0
1254	PI 220789	Afghanistan	7.5	2.0	6.0	9.0	0
1255	PI 171601	Turkey	7.5	1.8	6.0	9.0	0
1256	PI 167043	Turkey	7.5	2.1	6.0	9.0	0
1257	PI 343451	Russian Fed.	7.5	1.8	6.0	9.0	0
1258	PI 172840	Turkey	7.5	1.8	6.0	9.0	0
1259	PI 246930	Afghanistan	7.5	1.2	6.7	8.3	0
1260	PI 176523	Turkey	7.5	1.2	6.7	8.3	0
1261	PI 175694	Turkey	7.6	2.2	5.5	9.0	1
1262	PI 176522	Turkey	7.6	2.2	5.5	9.0	1
1263	PI 288237	Egypt	7.6	2.2	5.5	9.0	1
1264	PI 167389	Turkey	7.6	2.2	5.5	9.0	1
1265	PI 137851	Iran	7.6	1.3	6.5	8.3	1
1266	Ames 3949	Canada	7.7	1.0	7.0	8.3	0
1267	PI 169378	Turkey	7.7	1.6	6.3	9.0	0
1268	Ames 23009	Czech Republic	7.7	1.6	6.3	9.0	0
1269	PI 167052	Turkey	7.7	1.6	6.3	9.0	0
1270	PI 222099	Afghanistan	7.7	2.0	6.3	9.0	0
1271	PI 169304	Turkey	7.7	1.5	6.3	9.0	0
1272	PI 534540	Syria	7.7	1.5	6.3	9.0	0
1273	PI 177361	Turkey	7.7	1.6	6.3	9.0	0
1274	PI 458851	Russian Fed.	7.7	1.0	7.0	8.3	0
1275	PI 169382	Turkey	7.7	1.5	6.3	9.0	0

Appendix Table 1 Continued

1276	PI 171613	Turkey	7.7	1.6	6.3	9.0	0
1277	PI 204568	Turkey	7.7	1.5	6.3	9.0	0
1278	PI 342950	Denmark	7.7	1.6	6.3	9.0	0
1279	PI 267087	Russian Fed.	7.8	1.5	6.0	8.3	2
1280	PI 285608	Poland	7.8	1.1	7.0	8.3	1
1281	PI 525158	Egypt	7.8	1.6	6.0	9.0	1
1282	Ames 21224	United States	7.8	1.6	6.0	9.0	1
1283	PI 172842	Turkey	7.8	1.8	6.7	9.0	0
1284	PI 338236	Turkey	7.8	1.6	6.7	9.0	0
1285	PI 181752	Syria	7.8	1.3	6.7	9.0	0
1286	PI 181874	Syria	7.8	1.3	6.7	9.0	0
1287	PI 344350	Turkey	7.8	1.3	6.7	9.0	0
1288	Ames 19225	Russian Fed.	7.8	1.0	7.3	8.3	0
1289	PI 226509	Iran	8.0	1.4	6.5	9.0	1
1290	PI 169385	Turkey	8.0	2.0	5.0	9.0	2
1291	PI 212599	Afghanistan	8.0	1.3	7.0	9.0	0
1292	PI 169328	Turkey	8.0	1.7	6.0	9.0	3
1293	PI 172846	Turkey	8.0	1.1	7.0	9.0	0
1294	PI 137848	Iran	8.2	1.1	7.0	9.0	1
1295	PI 172852	Turkey	8.3	1.2	-	8.3	3
1296	PI 284699	Sweden	9.0	-	-	9.0	5
1297	Ames 7760	United States	-	-	-	-	6
1298	National Pickling	NSSL	-	-	-	-	6
1299	TMG-1	P.R. China	-	-	-	-	6
LSD (5%)			1.60		1.79	3.14	

z Mean of all ratings taken at week 5 after planting for North Carolina and Poland during 2005, 2006 and 2007.
y Mean of ratings taken at week 5 after planting for North Carolina during 2005, 2006 and 2007.
x Mean of ratings taken at week 5 after planting for Poland during 2005, 2006 and 2007.
w Each year and each location is considered a replication for a total of six replications.