1995 ANNUAL PROGRESS REPORT

concerning

COLONIAL BENTGRASS (AGROSTIS TENUIS) SIBTH.

BREEDING AND CULTIVAR DEVELOPMENT

Submitted by:

Dr. Bridget Ruemmele
Assistant Professor
Turfgrass Improvement

Dr. Joel Chandlee
Assistant Professor
Molecular Biology

University of Rhode Island

Jointly Sponsored By:
The United States Golf Association
and
University of Rhode Island

1 November, 1995

NOT FOR PUBLICATION VOLUME 95-2

EXECUTIVE SUMMARY

1995 Annual Colonial Bentgrass Progress Report

Principle Investigators: Dr. Bridget Ruemmele
Dr. Joel Chandlee

Technical Support: Ms. Pei-Yu Zeng
Graduate Research Assistant
Ms. Stephanie Legare, Research Assistant

Research Period: 1 November 1994 to 30 October 1995

Accessions continue to be added to the current germplasm collection. Four private companies have been actively involved with cooperative acquisition and assessment of materials introduced from this program. A fifth company is in negotiation for cooperative efforts with the intention of marketing into Europe as well as the United States. Two multi-day collection trips occurred in 1995. The major collection event included sites in Georgia, Kentucky, Tennessee, and Virginia. A second effort involved previously-unexplored areas of New England. Numerous opportunities in conjunction with other events permitted collection during single day travel.

Progeny from 140 additional collections were planted in Rhode Island in 1995 for turf trial evaluation. Earlier genotype collections determined to be superior in turf trials and brown patch resistance screening in Rhode Island have been planted into space plantings for seed production in both Oregon and Rhode Island. Additional polycross plantings were established in Rhode Island in Fall, 1995, including materials screened for brown patch resistance in greenhouse trials.

Ms. Pei-Yu Zeng, an M.S. degree student, completed advanced greenhouse screening trials for Rhizoctonia sp. (brown patch) resistance in 277 Colonial bentgrasses. She completed her degree in summer 1995. Posters have been presented on this work at two conferences.

Students in Drs. Ruemmele's and Chandlee's plant breeding and genetics class screened duplicate material to Ms. Zeng's efforts as a lab exercise in spring 1995. Some of Dr. William Rumball's material acquired from Rutgers' plots have shown superior brown patch resistance. Other accessions from various collection efforts have also demonstrated resistance to brown patch.

Molecular efforts have included successful preparation of both creeping and Colonial bentgrass in tissue culture suitable for gene transfer. We are seeking chitinase genes from multiple sources to introduce into these cultures using a newly-acquired gene gun.

INDEX

I. INTRODUCTION

The Colonial bentgrass breeding and cultivar development program was initiated by Emeritus Professor C. R. Skogley. Dr. Skogley received partial support for his breeding efforts from the USGA prior to the arrival of Dr. Bridget Ruemmele. After Dr. Ruemmele's arrival, the USGA increased its financial support beginning 1 February 1993 to encourage greater efforts in developing new Colonial bentgrass cultivars. The USGA was instrumental in providing access to germplasm from Dr. William Rumball's program in New Zealand from seed sent directly from New Zealand and plantings maintained at Rutgers University by Dr. Reed Funk. Primary emphasis of the project is improving Rhizoctonia spp. (brown patch) resistance, with additional goals to develop cultivars with improved cold hardiness, darker green leaf color, low maintenance requirements (reduced cultural inputs including fertilizers, pesticides, water), close mowing tolerance, recuperative ability and wear tolerance, retention of desired turf-type characters (fine texture, density, uniformity, evenness of growth), and hybridization with related species to improve traits noted above.

II. TECHNICAL SUPPORT PERSONNEL

Dr. Bridget Ruemmele, an assistant professor, was hired April 1991 to continue the program initiated by Dr. C. R. Skogley. She has a three-way appointment in research, extension and teaching with primary emphasis on plant improvement. Her approximate effort on this project is 20%.

Dr. Joel Chandlee, an assistant professor with research and teaching efforts in molecular biology, devotes approximately 5% effort on this project.

Ms. Pei-Yu Zeng began as a technical assistant in early 1993. She officially became a Master's student of this project in Fall 1993 when her support from USGA funding also

began, continuing for one year. Due to regulations regarding College tuition funding, Ms. Zeng's assistantship technically came from USDA funds. Three other full-time turf employees who would normally be paid from the USDA funds received partial payment from the USGA grant in an amount equivalent to Ms. Zeng's stipend. The College of Resource Development provided her tuition. Her research concentrates on brown patch screening in relation to cultivar improvement of Colonial bentgrasses.

Ms. Zeng was supported for the 1994-95 school year by a Graduate Research Assistantship from the University of Rhode Island College of Resource Development. **She received her degree during the summer of 1995 and is continuing for a Ph.D. under the guidance of Dr. Joel Chandlee. Two posters related to her M.S. work have been presented at two conferences, including the 1995 ASA-CSSA-SSSA Meeting.**

Ms. Zeng will continue at the University of Rhode Island to obtain a Ph.D. emphasizing molecular introduction of genes into turfgrasses. The project currently has both Colonial and creeping bentgrasses established as callus suitable for gene introduction.

Ms. Stephanie Legare was hired fall 1994 to replace Ms. Grace Wojcik and Ms. Kirsten Thornton. Ms. Legare was employed for 40 hours per week on USGA funding to continue until early May 1995. Her responsibilities include bentgrass germplasm and plot establishment and maintenance, record-keeping, data collection and processing. Her effort on this project is 100 percent. **Ms. Legare's responsibilities were assumed by various support personnel hired for Dr. Ruemmele's overall research program, one or more of whom were on USGA support since Ms. Legare's departure.**

Mr. Greg Fales, Mr. Donald Timpson, and Mr. Barry Prefontaine provide technical support in the field. Mr. Fales oversaw all operations, including additional student labor to maintain turf plots and prepare additional space for field plantings until he was replaced late this summer by Mr.

Christopher Raymond. Mr. Timpson assists Mr. Raymond. Mr. Prefontaine is a full-time mechanic who has been instrumental in constructing a wear machine for use in turf trials. He also provided expertise in getting the polyhouse functional for increased greenhouse work as well as maintaining all turf equipment and the field irrigation system. These employees are supported by the State of Rhode Island and/or various support obtained through the turfgrass research fund. The combined effort of field support personnel on bentgrass research was 20%.

Ms. Lisa Rowley is employed by Dr. Noel Jackson, U.R.I. turf pathologist, who has graciously permitted Ms. Rowley to assist in preparing materials for the brown patch screening efforts and providing assistance as needed to Ms. Zeng in conducting her brown patch screening. Ms. Rowley's M.S. from the University of Massachusetts dealt with this disease. Her efforts on the bentgrass project are intermittent, making assigning a percentage difficult. She is supported by private contributions.

Ms. Jane Knapp is employed by Dr. Chandlee as a research assistant. She has successfully prepared tissue cultures of Colonial and creeping bentgrass for gene introduction through molecular techniques. Her efforts on the bentgrass project are also intermittent, making assigning a percentage difficult. Ms. Knapp is supported by the University of Rhode Island.

III. ADDITIONAL FUNDING

This project has received support from several programs and members of the turf industry. The USDA, private turf companies, and College of Resource Development funding will provide employment for at least three high school students this summer. Part of their efforts will include planting, plot maintenance and seed harvest of bentgrasses.

As noted under the technical support section, the State

of Rhode Island and additional private funding support several field personnel as well as the salaries of Dr. Ruemmele and Dr. Chandlee. State and private funding also provide facilities and money for facility upkeep,

Federal Hatch funds are used primarily for equipment acquisition and maintenance and supplies.

The New England Golf Course Superintendents' Association has enthusiastically supported construction of a USGA specification green. Although initially planted to creeping bentgrasses, we hope to test Colonial bentgrasses in the future as they near release. We also constructed a 1500 square foot sand-based tee in late 1994 which would also be available for Colonial bentgrass performance testing. This project was funded by two private companies.

IV. PROGRESS AND RESULTS

A. GERMPLASM ACQUISITION

Primary emphases in the initiation of the program included assessment of existing germplasm and acquisition of additional plants to increase the germplasm base. Existing material came primarily from Dr. Skogley's collection efforts in New England. The collection included 175 bentgrasses classified as 'Colonial'. Additional plants were obtained from the New Zealand collections of Dr. William Rumball and collection trips from Maine to Pennsylvania and all states in between except Vermont.

Since arriving at the University of Rhode Island, Dr. Ruemmele has conducted several collection trips to golf courses, cemeteries, parks, old home lawns, and roadsides. At most sites, there was no known overseeding done within the past thirty years, or in many cases, ever. The variability in material was encouraging. Some collections may actually be hybrids between bentgrass species.

One goal for the first year of this research was to acquire germplasm from native or naturalized sites as well as from the New Zealand collection located at Rutgers University.

Material at Rutgers was evaluated three times in 1993. Selections were plugged from the site twice for evaluation in Rhode Island, with many currently planted in field space plantings as well as maintained in a greenhouse collection. Dr. Rumball was contacted since the last report regarding the status of his breeding material at the University of Rhode Island. No response has been received yet.

Including all species collected (bentgrasses and fine fescues), from 1 to 143 collections were obtained per site. The following list indicates the number of sites sampled by state:

Connecticut	25
Georgia	**5**
Kentucky	**5**
Maine	12
Massachusetts	**32**
New Hampshire	2
New York	13
Pennsylvania	2
Rhode Island	**45**
Tennessee	**14**
Virginia	**4**

Much area remains to be covered, including collections further south along the East Coast of the United States where higher humidity and heat conditions may be more favorable for obtaining brown patch resistant Colonial bentgrasses. **Dr. Reed Funk agreed to accompany me on some turfgrass collecting along the Eastern Coast this summer, but our schedules conflicted. Dr. Leah Brilman and I were able to conduct a preliminary collection in selected areas of Georgia, Kentucky, Tennessee, and Virginia. In addition to actual collection of sites numbered above, we also received additional leads for future exploration.** The sites of origin in Europe could also provide beneficial breeding material.

Greenhouse facilities include an approximately 1000 square foot polyhouse **exclusively** used for the turfgrass

improvement program, as well as up to 500 additional square feet in glasshouses. This has facilitated the ability to increase plantings from seed or vegetative propagules for field and greenhouse evaluations as well as providing a location for maintaining the germplasm collection. Most recently acquired germplasm has been propagated into deepots for preservation of purity. This material was increased in 1993 and 1994 for field planting and greenhouse disease screening, both of which began in late fall 1993 and continue to the present time. **A private plastics company has specially produced a new long-lasting (expanding the life 2-3 times normally expected) cover for the free-standing polyhouse at no cost to the turfgrass breeding program.**

B. FIELD EVALUATION

Goals include continued field screening of current space plant or close-seeded plot germplasm not assessed for at least two years for desirable turf traits and establishing space plant progeny rows and close-seeded plots of seed harvested from advanced selections in 1991 or earlier. Close-seeded plots are maintained under conditions simulating ultimate management practices and evaluated for quality as well as disease resistance.

Initial germplasm provided by Dr. Skogley has been evaluated for seed production, leaf color and texture, and growth habit. Natural infestations of brown patch have been lacking in the field the past three years, making greenhouse screening efforts and field inoculations more critical. The entire space planting was relocated in the summer of 1992 to make room for a new USGA specification green. **Selected seed harvested from this site yearly since 1992 was planted during 1995. Plants exhibiting superiority during two drought-stressed summers were retained from these plots for planting in polycross nurseries as well as continued space planting.**

Seed harvested from the original site was accumulated from two or more years' harvests to provide enough seed for

turf plot evaluations. Three selections planted in turf trials in 1992 continue to be evaluated. One is more promising than the other two. Additional seed was harvested in 1993 and 1994 from selected original space planting material for use in progeny space plantings and close-seeded plots. **These plots were seeded in Fall, 1995, along with additional seed collected in 1995.**

Cooperative collection efforts with private industry are forging associations which will enhance cultivar distribution of improved materials. One association has already produced progeny from 69 initial collections (See Appendix 1 in Fall, 1994 report). Seed planted in the fall of 1993 at the University of Rhode Island for turf trial evaluation in close-seeded plots survived the first year through a cold and snowy winter with varied degrees of success. **One selection distinguished itself for its dark color and good density. Roughly a half dozen additional selections were also marked for further study. Differential infestation of crabgrass continues under assessment for potential allelopathy.**

The highest quality plants were planted in polycross nurseries in Oregon in 1994. Vegetative material from each plot has also been screened for brown patch resistance in greenhouse screening procedures. **This material, also located in Oregon, has been rogued in Oregon based on brown patch screening and quality data of turf plots at URI, to limit pollen exchange among superior genotypes. Seed harvested from these plots in Oregon this summer is expected to be planted in turf plots at URI this fall, but has not been received to date.**

An additional 140 seed lots obtained in the Oregon plantings from joint collections (subsequent to the 69 initial collections noted above) were planted in close-seeded turf trials in Fall, 1995 in the same area as additional URI material from other sections of the breeding program.

The goal to complete single and polycrosses and self pollination of selected superior genotypes in the first year

was not entirely successful. Single and self pollinations were unable to be completed due to limited labor at time of pollination. Some flowering occurred during the winter 1993 in the greenhouse. Selected materials were bagged together for cross-pollination. Seed did not fill out as expected. Some germplasm collected in Fall 1994 flowered in the greenhouse this winter. It was not bagged, but seed will be harvested for turf establishment. Controlled pollinations will continue in field isolation plots in 1995.

One of the most severe droughts in the region occurred during the summer of 1993, followed by additional droughts in 1994 and 1995. The non-irrigated space plantings from the original bentgrass collection were examined for tolerance to these droughts. Selections were grouped into one of three categories: low, medium, or high drought resistance. One group of each classification, containing three to five parents each, was established in a polycross nursery for seed production 1994. **Seed was harvested in 1995 for a late fall planting this same year. Progeny will be evaluated for brown patch resistance and potential association to drought resistance.**

Germplasm collected since 1991 was increased vegetatively for field space planting. More than 600 plants were set in the field, including up to five clones of each accession by fall 1994. **Since the fall 1994 report, more than three thousand space plantings were established at the Agronomy Research Farm adjacent to the Turfgrass Research Farm. Dr. Ruemmele was designated in charge of this facility this spring as well, more than doubling land immediately available for turf breeding. Several genotypes included in the current space planting were designated superior in brown patch resistant during greenhouse screening trials conducted by Ms. Zeng. These plants are undergoing evaluation in the field for growth characteristics and seed collection.**

C. GREENHOUSE EVALUATION

During the first year, plans included conducting greenhouse screening of current germplasm for brown patch resistance. Ms. Pei-Yu Zeng, a Master's Degree student, officially began working with this project in fall 1993. Her thesis concentrates on Rhizoctonia sp. (brown patch) resistance screening in bentgrasses.

Plants were increased between 1992 - 1994 for screening as well as field planting (Photographs 1 through 5 in Fall 1994 report). Four replications were used in brown patch screening for most accessions.

The greenhouse expansion has facilitated the ability to increase plantings from seed or vegetative material for field and greenhouse evaluations as well as providing the requisite area for doing the actual greenhouse screening. Seed collected in 1993 was germinated in 1994 from 57 bentgrass selections for progeny evaluations.

Eight isolates of Rhizoctonia solani (Appendix 3 in Fall 1994 report) were incubated for inoculating greenhouse materials beginning in late 1993 through early 1994 using infected grains as the inoculum source. A meeting among Dr. Ruemmele, Ms. Zeng, and Ms. Rowley in November established the inoculation procedure and timing for screening bentgrasses.

Ms. Zeng conducted four preliminary experiments using 8 to 13 genotypes inoculated with each of the eight brown patch isolates plus a control that was not inoculated (Appendices 4 through 7 in Fall 1994 report). Each treatment was replicated four times in each experiment.

The first experiment determined that more inoculum than originally planned may be necessary to induce enough disease for plant resistance assessment (Appendix 4 in Fall 1994 report). One isolate was most severe, with three others in the second most severe group.

Re-treatment of the original plants was a part of the second experiment (Appendix 5 in Fall 1994 report). Despite good mycelial growth in the second experiment, heat may have

been a greater factor than the fungus in killing plants in this experiment. Three isolates produced more fungal growth than the others.

Four isolates produced the most plant damage in experiment three, with one superior to the other three (Appendix 6 in Fall 1994 report). Nine bentgrass clones were used in this experiment.

The fourth preliminary experiment (Appendix 7 in Fall 1994 report) included 27 bentgrass clones. Isolates 4, 5, and 8 produced the most severe damage to grasses.

Based on the four preliminary experiments, isolates 4, 5, and 8 were selected for advanced brown patch screening. **Eight advanced experiments have been completed, using several bentgrass clones each as follows:**

Experiment Number	**Number Clones Tested**
1	**11**
2	**36**
3	**32**
4	**28**
5	**40**
6	**42**
7	**24**
8	**64**

Each plant was inoculated with 10 seeds of infected perennial ryegrass and covered by plastic covers for the next 96 hours. Quality notes were recorded to determine the degree of plant damage caused by the disease. Plants with the most resistance were retained for planting in field trials.

Students in Drs. Ruemmele's and Chandlee's plant breeding and genetics class screened duplicate material to Ms. Zeng's efforts as a lab exercise in spring 1995. Some of Dr. William Rumball's material acquired from Rutgers' plots have shown superior brown patch resistance in both Ms. Zeng's and the class experiments.

Complete results of Ms. Zeng's screening trials are included in the appendix to this annual report.

D. VERIFICATION OF FUNGAL ISOLATES AND THEIR UNIQUENESS

The fungus was re-isolated from inoculated plants to confirm infection by the original strains as described in the fall 1994 report. Polymerase chain reaction (PCR) was conducted to confirm the identity of the inoculum and re-isolations as the same, as well as to determine that the eight strains were different from each other (Fall 1994 report).

Additional isolates may be sought from Drs. Phil Colbaugh and Henry Wilkinson, turf pathologists with collections of particularly virulent Rhizoctonia spp.

E. MOLECULAR EVALUATION

Random Amplified Polymorphic DNA (RAPD) technology was used to analyze numerous genomic DNA preparations. The objective was to identify genetic markers which could be used to 'fingerprint' plants and assist breeding efforts by identifying genes associated with morphological or physiological traits. Initial molecular identification screening was difficult due to contamination in field plots. Fine fescues provided clearer results and have become the basis for the Ph.D. of Ms. Sardha Suryapperuma, who conducted this research. Another research assistant in Dr. Chandlee's lab, Ms. Jane Knapp, has successfully prepared both creeping and Colonial bentgrass tissue cultures suitable for gene transfer via bombardment. **We are currently trying to determine available chitinase genes for conferring brown patch resistance.**

F. USGA SPECIFICATION GREEN

The New England Golf Course Superintendents' Association has enthusiastically supported construction of a USGA specification green. Although initially planted to creeping bentgrasses, we hope to test Colonial bentgrasses in the future as they near release.

V. FUTURE WORK PLANNED

1. **Germplasm collection**: Continue acquisition of germplasm from native or naturalized sites, particularly along the Southeast U.S. coastline. **A cooperative trip in Southeastern United States with a breeder from a private company completed in Fall, 1995 revealed additional information for future collection. Additional collection trips should include one along the Eastern Coast in conjunction at least partly with Dr. Reed Funk as well as other day collection trips with two local private company representatives.**

Work cooperatively with Dr. Bill Rumball, who has contacted this program regarding this matter. **Return correspondence by Dr. Ruemmele has not yet been answered.**

Plan germplasm collection trip to Eastern Europe -- a private company has expressed interest in a European collection trip. Germplasm acquisition is critical to obtain the most diverse representation of available material. Expanding the germplasm base increases the opportunity to improve Colonial bentgrasses, particularly with respect to brown patch resistance.

2. **Current field screening**: Continue field screening of current and additional space plant or close-seeded plot germplasm not assessed for at least two years for desirable turf traits. The best plots will be selected for expanded trials and/or going back to original parental material to use for further species improvement in single or multiple crosses.

3. **New plant screening**: Establish space plant progeny rows and close-seeded plots of seed harvested from pollination and advanced selections chosen in the previous year. Conduct greenhouse screening of germplasm not previously screened for brown patch resistance. Additional beneficial greenhouse and laboratory screening for desirable genotype improvement will be incorporated as they become available.

Progeny selected from space plantings, close-seeded

plots, or screening procedures will be placed in polycross nurseries or isolated for self or single outcrosses for seed production. Greenhouse-screened material will also be field planted if grown from seed which was never grown under field conditions.

4. Controlled pollinations: Complete single and polycrosses and self pollination of additional selected superior genotypes. Continue screening for brown patch resistance and plant in field trials for turf characteristic evaluation.

5. Regional trials: If enough seed is available, establish regional turf trials of advanced superior genotypes.

By the completion of the third year, additional brown patch resistant material present in the URI collection will be determined in addition to previously screened material. Advanced material currently in field production will be thoroughly evaluated and documented for turf potential. Additional seed harvests from current plantings and polycross nurseries will be used to initiate new cycles of plot evaluations. Selections deemed advanced enough to warrant seed production trials will be sent to Oregon. Progeny from material already sent to Oregon will have been screened in one or more years of turf-type trials in Rhode Island. New plant acquisitions will be subjected to the rigors of evaluation to continue the process of cultivar enhancement.

VI. EXPENDITURES

As of my most current report (9/29/95) from the URI accounting office regarding officially recorded expenditures, the following are indicated. Additional money has been encumbered, but not recorded as spent for the labor of Ms. Colwell. This lack of recording is due to the slow process of completing paperwork at this University.

Ms. Zeng's Graduate Research Assistant Stipend (exchanged with another employee on USDA funding as indicated in section II; 93-94 academic year)	$9,550	
Ms. Grace Wojcik, hourly salary	7,200	
Ms. Kirsten Thornton, hourly salary	2,800	
Ms. Stephanie Legare, hourly salary	7,700	
Student employment, partial or full funding of 1 to 3 students throughout each year	7,011	
Employee benefits	4,420	
Salaries and benefits		$38,680
Office expenses	9	
Greenhouse building supplies	500	
Greenhouse and field supplies	501	
Operating expenses		1,010
Germplasm collection trips (includes posted encumbered and discharged funds)		325
University overhead		6,388
Total committed for three years		$46,403
Total remaining for third year (to 2-1-96)		$16,647

Most of the remaining amount has been or will be encumbered for student salaries, although this type of encumbrance is not recorded by our accounting office until actually expended. An additional $2,309 is also budgeted, but not yet charged against this account for overhead expenditure. Two trips have also not been charged yet to this account -- a collection trip already completed covering areas within the Southeastern United States and the November, 1995 ASA-CSSA-SSSA meeting, where a poster on Ms. Zeng's graduate work will be presented. Any remaining funding is expected to go toward collection day trips and greenhouse, field, and office expenses.

APPENDIX A. IDENTIFICATION OF COLONIAL BENTGRASS GENOTYPES WITH THE MOST BROWN PATCH RESISTANCE.

Two hundred seventy-seven Colonial bentgrasses (Appendix B) were screened using the three most damaging isolates (RS4′, RS5′, and RS8′, described in Table 1). Due to space limitations, genotypes were divided into eight experiments, with each experiment analyzed separately. Since the screening process conducted as part of an actual turfgrass breeding program would be performed on an on-going basis at different times of the year, decisions as to superior disease-resistant genotypes would be based on comparisons within each set of plants screened, rather than waiting until the last genotype has been screened (which may be several years after the first testing). Two experiments (6 and 8) produced data sets too large to be analyzed using PC-SAS. These experiments were split approximately in half for analysis and reporting.

In experiment 1, 11 Colonial bentgrass genotypes were evaluated for response to each isolate. Eight days after inoculation, RS5′ generally caused the most damage, followed by RS4′ and RS8′. Plugs inoculated by RS8′ began recovery soonest. Nine days after inoculation, RS5′-treated plugs still displayed the most severe symptoms, followed by RS4′ and RS8′.

Genotypes responded differently to each isolate of *Rhizoctonia solani*. For example, RS8′ caused extreme damage on genotype 3 (see Appendix B, 'G3'), but genotype 2 suffered more damage from RS4′ and RS5′ than RS8′ (Table 2). This finding indicates that resistance to different isolates of *Rhizoctonia solani* may be controlled by different genes. One variety may carry certain gene(s) resistant to RS8′, but sensitive to other isolates, while other varieties could carry gene(s) resistant to RS4′, RS5′, or other isolates. Figure 1 shows six representative genotypes from the 11 genotypes used in this experiment. Genotypes 11 and 5 showed more resistance to the three isolates than genotypes 4, 6, 2 and 7 (Figure 1).

Quality ratings of genotypes 11 and 5 indicate that these genotypes were significantly more resistant than the other nine genotypes (Table 2).

Thirty-six Colonial bentgrass genotypes were tested in experiment 2. Five and six days after inoculation, RS4' generally caused the most plant damage, while RS5' induced the least damage. Two days later, genotypes inoculated with RS8' had recovered faster than those inoculated with RS5'. RS4' still incited the worst symptoms, while the RS8' caused the least damage. Genotypes 18 and 33 were significantly more resistant to the three isolates of *Rhizoctonia solani* than the other genotypes (Table 3).

In experiment 3, thirty-two Colonial bentgrass genotypes were assessed for brown patch resistance. Six days after inoculation, RS8' caused the most damage and RS5' induced the least. Twelve days after inoculation, genotypes inoculated with RS8' recovered faster than those inoculated with RS4'. RS5' affected quality the least. Based on statistical analysis (Table 4), genotypes 54 and 55 were more resistant to the three isolates of *Rhizoctonia solani* than 25 other genotypes. Genotypes 50, 51, 56, 73, and 75 also expressed better resistance than most other genotypes (Table 4).

Twenty-eight Colonial bentgrass genotypes were evaluated in experiment 4. On genotype 80, RS4' induced the most damage, plugs of the same genotype inoculated with RS5' and RS8' recovered after thirty days. Most plugs of genotype 92 inoculated with RS4' recovered from disease symptoms, while most of the plugs inoculated with RS5' and RS8' still showed extreme disease symptoms after several days. These results suggest that genotype 80 may carry gene(s) resistant to RS5' and RS8', while genotype 92 may carry gene(s) resistant to RS4'.

Five and nine days after inoculation, RS8' caused the most damage averaged across all 32 genotypes; RS5' caused the least damage. Twelve days after inoculation, genotypes inoculated with RS8' recovered faster than those by RS4 and

RS5, with RS4′ inducing the worst symptoms on genotypes. Genotypes 81, 83, 98 and 99 were significantly more resistant to fungal inoculation than the genotypes tested in this experiment (Table 5).

Forty Colonial bentgrass genotypes were screened against RS4′, RS5′, and RS8′ in experiment 5. Averaged across all genotypes, RS5′ caused the worst damage, followed by RS8′ and RS4′. Genotype 136 showed significantly more resistance to the three isolates than the other 39 genotypes (Table 6).

In experiment 6, 42 Colonial bentgrass genotypes were evaluated. Due to limitations with the statistical software, the data set was divided for analysis among isolates. RS8′ induced the most damage averaged across genotypes 148 to 168, while RS5′ caused the least damage. On genotype 169 to 189, RS8′ caused the most damage, with RS5′ inducing the least damage. Six representative genotypes from all 42 genotypes are shown in Figure 2. Genotypes 156, 167, 153, and 151 showed more resistance to RS4′, RS5′, and RS8′ than genotypes 187 and 172. Genotypes 150 and 174 rated significantly higher for quality than 35 other genotypes in this experiment (Table 7). Genotypes 156, 157, 164, 166, and 182 were not significantly different from genotypes 150 and 174.

RS4′, RS5′, and RS8′ were used to inoculate 24 genotypes in experiment 7. RS5′ caused the most damage and RS8′ caused the least damage when averaged across all genotypes. Figure 3 shows six representative genotypes, with genotype 199 and 202 more resistant to damage than genotypes 191, 193, 194, and 201. Statistical analysis of quality placed 14 genotypes in the most resistant group (genotypes 190, 195, 196, 198, 199, 202, 204, 205, 206, 207, 210, 211, 212, and 213) (Table 8).

In experiment 8, 64 Colonial bentgrasses were screened. As in experiment 6, the data set required division for statistical analysis. Among genotypes 214 to 245, RS4′ caused the most damage, while RS5′ caused the least damage. RS8′ caused the most damage on genotypes 246 to 277, compare to RS5′ and RS4′. Nine genotypes (224, 225, 227, 228, 244, 256,

258, 273, and 274 ranked in the highest statistical group for quality (Table 19).

GENERAL DISCUSSION

Each bentgrass germplasm responded differently to each isolate. This suggests that different genes for pathogenicity may exist in each isolate, and this makes the selection and identification of isolates used in a breeding program critical. Although the traditional method of the anastomosis grouping can distinguish groups of fungal isolates, the RAPD-PCR is another useful technique for distinguishing within the groups of isolates. Due to the ability to naturally cross pollinate, Colonial bentgrass is heterozygous, producing genetic variation necessary for plant improvement. In these experiments, some genotypes appeared strongly resistant to the three most aggressive isolates of *Rhizoctonia solani*, while others were extremely sensitive. This suggests that genes for resistance to *Rhizoctonia solani* exist in some genotypes.

SUMMARY

Using the large-scale brown patch screening method, resistance could be selected for on the basis of the response of each genotype to inoculation by *Rhizoctonia solani* isolates. This technique provided a suitable, rapid, large volume screening procedure for selecting brown patch-resistant Colonial bentgrass germplasm.

Tables for Appendix A.

Table 1. Cultures[1] of *Rhizoctonia solani* used in brown patch screening in greenhouse. Eight isolates of *Rhizoctonia solani* obtained January 19, 1994 from the collection of Dr. Noel Jackson:

Isolate	Group	Grass type	Collection source
RS1	AG1	creeping bentgrass	Penncross sod
RS2	AG1	creeping bentgrass	D. Wallace sod
RS3	AG2-2	velvet bentgrass	Turf farm
RS4	AG1	Kentucky bluegrass	New England Turf
RS5	AG1	perennial ryegrass	Segregansett G.C.
RS6	AG1	creeping bentgrass	Turf farm
RS7	AG2-2	unknown	Turf farm
RS8	AG1	tall fescue, cv. ISI-ATK	URI cultivar test plots

[1] Cultures of each isolate were grown in 100mm X 15mm petri dishes containing 10ml sterilized potato dextrose broth. After retransfers on 19, 22, 28 January and 4 February, pure cultures with no contamination were obtained.

Table 2. Quality ratings (1-9, 9 = no disease symptoms) of the eleven genotypes used in experiment 1 testing the ability of three isolates of *Rhizoctonia solani* (RS4′, RS5′, and RS8′) to induce disease in Colonial bentgrass germplasm. Each mean is an average of all three isolates.

GENO-TYPE	DAY 7	DAY 8	DAY 9	DAY 10	DAY 11	DAY 13
G1	4.4ab[1]	4.7ab	4.4cd	4.5cde	4.9de	5.4de
G2	3.9cde	4.2abc	4.3de	4.3de	4.6f	4.9ef
G3	3.6e	3.7c	3.7f	3.8f	4.1g	4.9f
G4	4.5ab	4.9a	4.3de	4.4cde	5.1cd	5.4bcd
G5	4.7a	4.9a	4.7b	5.1ab	5.9a	6.3a
G6	4.1bc	4.7ab	4.5cd	4.6cd	4.7efg	5.2d-g
G7	3.6de	4.2abc	4.1e	4.2e	4.5f	4.8fg
G8	4.0cd	4.4abc	4.5cd	4.7cd	5.4bc	5.8b
G9	3.9cde	4.4abc	4.6bc	4.8bc	5.4b	5.7bc
G10	3.9cde	3.9cde	4.5cd	4.6cd	4.6f	4.9ef
G11	3.9cde	3.9cde	5.4a	5.4a	6.1a	6.6a

[1] Means within a column followed by the same letter are not significantly different using the Waller-Duncan mean separation test (k-ratio = 100).

Table 3. Quality ratings (1-9, 9 = no disease symptoms) of the 36 genotypes used in experiment 2 testing the ability of three isolates of *Rhizoctonia solani* (RS4', RS5', and RS8') to induce disease in Colonial bentgrass germplasm. Each mean is an average of all three isolates.

GEN.	DAY 5	DAY 6	DAY 7	DAY 8	DAY 9	DAY 12	DAY 14	DAY 15	DAY 16	DAY 25	DAY 27
G12	3.8 c-f[1]	3.8 a-d	3.8 a-d	3.8 d-g	3.8 f-l	4.3 d-j	4.0 h-l	4.3 f-l	5.2 f-m	6.0 g-k	6.1 g-j
G13	4.0 ab	3.8 a-d	3.8 a-e	4.4 a	4.6 a	5.1 ab	5.0 a-d	5.0 a-d	6.0 a-d	7.0 abc	7.2 ab
G14	4.0 a	3.9 a	4.0 ab	4.3 ab	4.4 ab	4.9 bc	5.1 abc	5.1 ab	5.6 d-h	6.4 c-g	6.4 c-h
G15	3.5 g-m	3.5 f-m	3.5 e-j	3.8 e-i	3.8 f-l	4.4 c-h	4.6 a-f	4.7 b-g	5.8 a-e	6.9 a-e	6.9 b-f
G16	3.2 nop	3.3 lmn	3.2 klm	3.3 lm	3.4 mn	3.9 j-m	3.8 i-l	4.0 i-m	5.1 g-m	5.9 ghi	6.3 fgh
G17	3.5 g-m	3.4 h-m	3.5 g-k	3.9 c-f	4.1 c-g	4.4 c-h	4.3 e-i	5.0 a-d	5.6 d-j	6.3 d-i	6.6 b-g
G18	3.4 h-n	3.6 c-i	3.6 d-h	3.9 c-f	3.9 d-h	4.6 b-e	4.6 b-f	4.8 b-f	6.4 ab	7.4 ab	7.7 a

G19	3.8 a-c	3.9 a	3.9 a-c	4.1 abc	4.4 abc	4.8 bcd	5.0 abc	5.0 a-d	6.2 abc	7.0 abc	7.3 ab
G20	3.6 c-j	3.4 g-m	3.4 g-k	3.5 h-m	3.5 k-n	4.0 g-n	3.9 i-l	3.9 i-m	4.6 mn	5.3 klm	5.3 kl
G21	3.7 c-g	3.5 e-l	3.6 d-i	3.7 f-k	3.9 e-k	4.3 d-j	4.5 d-h	4.5 d-j	5.2 f-m	6.3 c-h	6.4 e-h
G22	3.4 i-o	3.3 j-n	3.5 g-k	3.5 h-m	3.5 k-n	4.0 h-n	3.9 h-l	4.0 i-m	5.1 h-m	5.8 g-l	5.9 g-k
G23	3.8 c-f	3.5 d-k	3.6 d-i	3.7 e-j	3.9 d-l	4.5 c-f	4.6 b-g	4.7 b-h	5.8 b-f	6.2 e-i	7.2 abc
G24	3.4 i-o	3.4 i-n	3.4 h-m	3.4 j-m	3.5 j-n	3.8 k-n	4.0 h-l	4.1 i-m	4.6 mn	5.4 j-n	5.5 i-l
G25	3.3 j-p	3.4 h-m	3.4 h-l	3.5 h-m	3.6 h-n	4.0 h-n	3.9 i-l	4.1 i-m	4.9 k-n	5.8 g-l	5.9 g-k
G26	3.3 l-p	3.3 k-n	3.3 i-m	3.3 lm	3.4 n	3.6 n	3.6 kl	3.7 lm	4.3 n	4.9 n	5.0 l
G27	3.8 c-f	3.8 abc	3.8 a-e	3.9 c-f	4.2 b-e	4.5 c-g	4.8 a-e	4.9 b-e	5.7 c-g	5.8 g-l	6.0 g-k
G28	3.7 c-h	3.6 c-j	3.6 d-h	3.8 e-i	3.9 d-j	4.2 e-l	4.3 e-j	4.5 c-i	5.6 d-i	6.3 d-i	6.4 d-h

G29	3.5 e-l	3.4 h-m	3.4 h-l	3.4 j-m	3.5 k-n	3.8 k-n	4.1 g-l	4.0 i-m	4.8 ln	5.0 mn	5.3 k-l
G30	3.8 bcd	3.8 abc	3.8 a-e	4.1 b-d	4.3 a-d	4.5 c-g	4.8 a-e	4.7 b-h	5.5 d-k	5.7 h-m	5.8 h-k
G31	3.3 k-p	3.3 ln	3.3 j-m	3.4 lm	3.5 lmn	3.9 i-n	3.8 i-l	3.9 j-m	4.8 lmn	5.6 i-n	5.8 h-k
G32	3.6 c-i	3.5 f-m	3.5 g-k	3.9 c-f	4.1 b-g	4.9 bc	5.1 ab	5.1 abc	6.3 ab	7.3 ab	7.2 abc
G33	3.6 d-k	3.5 f-m	3.5 f-j	4.0 c-e	4.2 b-f	4.5 c-g	4.7 a-e	4.9 b-e	6.4 a	7.5 a	7.7 a
G34	3.1 p	3.1 n	3.1 m	3.3 m	3.4 n	3.6 n	3.6 l	3.5 m	4.6 mn	5.2 mn	5.5 i-l
G35	3.5 g-m	3.3 j-n	3.4 h-m	3.6 g-l	3.8 g-m	3.7 mn	4.1 g-l	4.1 h-l	5.0 j-m	5.7 g-m	5.9 g-k
G36	3.2 m-p	3.2 mn	3.2 klm	3.3 lm	3.5 lmn	3.7 mn	3.7 kl	3.7 lm	4.6 mn	5.3 lmn	5.4 j-n
G37	3.8 b-e	3.5 f-m	3.5 f-j	3.7 f-k	3.6 h-n	4.0 g-n	4.5 c-g	4.7 b-h	5.8 b-f	6.8 a-e	7.1 a-d
G38	3.5 g-m	3.1 n	3.2 lm	3.3 m	3.3 n	3.9 i-n	3.8 i-l	4.0 i-m	4.8 lmn	5.4 j-n	5.8 h-k

G39	4.0 ab	3.9 ab	4.0 a	4.1 bcd	4.3 a-d	4.1 f-m	5.2 a	5.2 ab	6.1 a-d	6.7 b-f	7.2 ab
G40	3.6 c-j	3.7 b-h	3.7 c-g	3.8 d-h	3.9 e-k	4.5 c-g	4.6 b-f	4.7 b-h	5.4 e-l	5.8 g-l	6.2 f-i
G41	3.5 e-l	3.3 k-n	3.3 j-m	3.4 k-m	3.6 i-n	3.7 lmn	3.8 jkl	4.0 i-m	5.0 i-m	6.0 f-j	6.3 fgh
G42	3.2 op	3.3 k-n	3.3 j-m	3.4 klm	3.6 i-n	3.8 k-n	4.0 h-l	4.1 i-m	5.0 j-m	5.6 i-n	5.8 h-k
G43	3.7 c-g	3.8 a-e	3.7 c-g	3.9 c-f	4.1 bcd	4.6 bg	4.8 a-e	5.1 ab	6.0 a-d	6.9 a-d	7.2 ab
G44	3.6 c-i	3.7 a-g	3.8 b-f	3.8 e-h	3.8 f-k	4.2 f-k	4.5 c-g	4.9 b-e	5.4 d-k	6.3 c-h	6.4 c-h
G45	3.5 g-m	3.5 f-m	3.4 h-m	3.8 d-i	4.0 c-g	4.1 f-m	4.0 h-l	4.2 g-l	4.7 mn	5.3 k-m	5.8 h-k
G46	3.7 c-g	3.7 a-f	3.7 c-g	3.9 c-f	4.2 b-e	5.1 ab	5.0 a-d	5.5 a	6.4 ab	7.1 ab	7.3 ab
G47	3.5 f-l	3.6 c-j	3.4 h-m	3.7 f-k	3.9 d-h	4.0 g-n	4.1 f-k	4.2 g-l	5.5 d-j	6.7 b-f	7.0 a-e

[1] Means within a column followed by the same letter are not significantly different using the Waller-Duncan mean separation test (k-ratio = 100).

Table 4. Quality ratings (1-9, 9 = no disease symptoms) of the 32 genotypes used in experiment 3 testing the ability of three isolates of Rhizoctonia solani (RS4, RS5, and RS8) to induce disease in Colonial bentgrass germplasm. Each mean is an average of all three isolates.

GEN.	DAY 5	DAY 6	DAY 7	DAY 8	DAY 9	DAY 12	DAY 14	DAY 16	DAY 19	DAY 25
G48	3.3 b-e[1]	3.3 b-f	3.4 a-e	3.5 abc	3.6 a-e	3.7 b-g	3.9 a-h	4.1 a-f	4.3 cde	4.4 b-f
G49	3.4 abc	3.5 ab	3.5 abc	3.7 a	3.8 abc	3.8 a-d	3.9 a-f	4.1 a-f	4.3 cde	4.4 b-f
G50	3.4 a-d	3.4 a-d	3.5 abc	3.6 ab	3.7 a-d	4.0 abc	4.1 abc	4.4 abc	4.5 a-d	4.8 abc
G51	3.2 c-g	3.3 c-g	3.4 a-e	3.5 abc	3.6 a-f	3.8 a-d	3.9 a-g	4.1 c-h	4.3 c-f	4.5 a-e
G52	3.3 b-f	3.3 c-g	3.3 b-g	3.4 b-f	3.6 b-g	3.7 b-h	3.8 b-i	4.0 c-i	4.3 c-f	4.5 b-f
G53	3.2 e-i	3.2 f-j	3.2 d-h	3.3 c-h	3.3 e-k	3.4 f-l	3.6 e-l	3.8 e-k	3.9 e-h	4.0 d-k
G54	3.4 ab	3.4 abc	3.5 ab	3.7 a	3.8 ab	4.0 ab	4.2 ab	4.6 a	4.9 ab	5.1 a

G55	3.5 a	3.5 a	3.6 a	3.6 ab	3.9 a	4.1 a	4.3 a	4.6 ab	4.9 a	5.1 a
G56	3.1 e-i	3.2 e-i	3.4 a-d	3.5 abc	3.6 a-e	3.8 a-f	4.0 a-d	4.2 a-e	4.4 b-e	4.8 ab
G57	3.0 i	3.0 j	3.0 hi	3.1 h	3.2 ijk	3.2 h-l	3.5 g-m	3.6 g-k	3.9 e-h	4.1 d-j
G58	3.1 e-i	3.1 f-j	3.2 d-h	3.3 c-h	3.5 c-i	3.6 d-i	3.8 b-i	4.1 c-h	4.3 c-f	4.4 b-f
G59	3.1 e-i	3.1 f-j	3.3 c-g	3.4 b-f	3.4 c-j	3.5 e-k	3.7 d-k	3.9 c-j	4.1 d-g	4.2 b-h
G60	3.0 hi	3.0 j	3.1 hi	3.1 h	3.1 jk	3.1 kl	3.2 lm	3.3 k	3.4 h	3.4 k
G61	3.1 ghi	3.1 g-j	3.1 ghi	3.2 fgh	3.3 f-k	3.4 g-l	3.4 i-m	3.5 ijk	3.9 e-h	4.0 d-k
G62	3.0 i	3.0 j	3.0 i	3.1 h	3.1 jk	3.2 jkl	3.3 j-m	3.3 k	3.5 g-k	3.6 ijk
G63	3.0 hi	3.1 ij	3.1 ghi	3.2 d-h	3.3 g-k	3.3 i-l	3.4 j-m	3.5 ijk	3.7 gh	3.8 g-k
G64	3.0i	3.0j	3.0hi	3.1h	3.1jk	3.2kl	3.2lm	3.3k	3.4h	3.5k

G65	3.0 i	3.1 g-j	3.2 e-i	3.2 d-h	3.4 d-j	3.5 e-k	3.6 e-m	3.7 f-k	3.9 e-h	4.1 d-i
G66	3.0 i	3.0 j	3.0 hi	3.1 h	3.1 jk	3.2 kl	3.3 k-m	3.3 k	3.4 h	3.5 jk
G67	3.2 d-h	3.3 c-g	3.3 b-g	3.4 a-e	3.6 b-g	3.7 c-h	3.8 b-i	3.9 c-j	4.1 d-g	4.3 b-g
G68	3.1 ghi	3.1 f-j	3.2 e-i	3.2 d-h	3.3 e-k	3.5 d-j	3.7 c-j	4.0 c-i	4.0 d-g	4.2 c-h
G69	3.0 hi	3.1 hij	3.1 ghi	3.2 e-h	3.2 h-k	3.4 g-l	3.5 g-m	3.5 ijk	3.7 gh	3.8 g-k
G70	3.1 f-i	3.1 g-j	3.1 ghi	3.2 e-h	3.3 g-k	3.4 f-l	3.5 g-m	3.5 ijk	3.7 gh	3.8 g-k
G71	3.2 e-i	3.1 f-j	3.2 e-i	3.3 c-h	3.3 e-k	3.4 f-l	3.5 f-m	3.6 g-k	3.9 e-h	3.9 e-k
G72	3.0 i	3.0 j	3.0 hi	3.1 gh	3.2 ijk	3.3 jkl	3.4 j-m	3.4 jk	3.8 fgh	3.9 e-k
G73	3.2 e-i	3.3 d-h	3.3 b-f	3.4 a-e	3.6 a-e	3.8 a-e	4.0 a-e	4.3 a-d	4.6 abc	4.8 ab
G74	3.1 ghi	3.1 hij	3.1 f-i	3.2 fgh	3.3 e-k	3.4 g-l	3.6 e-m	3.8 e-k	3.9 e-h	4.1 d-i

G75	3.2 e-i	3.3 d-h	3.3 b-g	3.4 a-e	3.6 b-g	3.7 b-g	3.9 a-h	4.0 c-h	4.4 b-e	4.6 a-d
G76	3.2 e-i	3.3 d-h	3.3 c-g	3.4 b-g	3.4 c-j	3.6 d-j	3.7 c-j	3.9 d-j	4.0 d-g	4.1 d-i
G77	3.1 ghi	3.1 ij	3.0 hi	3.1 h	3.1 k	3.1 l	3.2 m	3.3 k	3.6 gh	3.7 h-k
G78	3.1 e-i	3.1 f-j	3.2 e-i	3.2 d-h	3.4 e-k	3.4 f-l	3.6 e-l	3.8 d-j	4.1 d-g	4.1 d-i
G79	3.3 b-f	3.4 a-e	3.4 a-e	3.5 a-d	3.5 b-h	3.7 c-i	3.9 a-g	4.1 c-h	4.3 c-f	4.5 b-f

[1] Means within a column followed by the same letter are not significantly different using the Waller-Duncan mean separation test (k-ratio = 100).

Table 5. Quality ratings (1-9, 9 = no disease symptoms) of 28 plants in experiment 4 testing the ability of three isolates of Rhizoctonia solani (RS4, RS5, and RS8) to induce disease in Colonial bentgrass germplasm. Each mean is an average of all three isolates.

GEN.	DAY 5	DAY 6	DAY 7	DAY 8	DAY 9	DAY 12	DAY 14	DAY 17	DAY 18	DAY 24	DAY 26	DAY 30
G80	4.6 ab[1]	4.5 b	4.3 bcd	4.4 bcd	4.5 cde	4.8 cd	5.1 cd	5.9 bcd	5.3 e-h	5.4 cd	5.8 bcd	6.7 bc
G81	4.7 ab	4.8 a	4.7 a	4.7 ab	5.1 a	5.5 a	6.0 a	6.6 a	5.9 bcd	6.0 bc	6.5 a	7.4 a
G82	4.6 ab	4.5 ab	4.4 abc	4.3 cde	4.5 cde	4.8 c	5.1 cd	6.3 abc	5.8 cde	4.9 d-g	5.7 cd	6.6 bc
G83	4.8 a	4.7 ab	4.7 a	4.6 ab	4.8 ab	4.9 bc	5.4 ab	6.4 ab	6.5 ab	5.3 d	6.4 ab	7.2 ab
G84	3.5 klm	3.4 i-l	3.4 l-o	3.4 j-m	3.4 j-o	3.6 i-m	3.8 h-l	4.2 i-l	4.1 lmn	4.3 hij	4.3 f-i	5.2 ef
G85	3.6 j-m	3.5 h-k	3.5 j-m	3.5 ijk	3.6 il	3.6 h-l	3.7 h-l	3.8 k-n	3.8 h-r	4.1 ijk	3.8 ijk	4.2 h-k
G86	3.6 jkl	3.5 h-l	3.5 j-m	3.4 i-l	3.5 j-m	3.6 h-l	3.9 g-j	4.0 jkl	4.0 mno	3.9 jkl	4.1 g-j	4.1 i-l

G87	3.6 jkl	3.5 g-j	3.5 jkl	3.6 ijk	3.7 ijk	3.8 g-j	3.9 g-j	4.1 i-l	3.9 m-q	4.0 ijk	3.9 h-k	4.8 f-i
G88	3.6 jk	3.4 jkl	3.5 j-m	3.3 klm	3.4 k-o	3.4 j-m	3.5 i-l	3.5 lmn	3.5 o-q	3.7 klm	3.9 ijk	3.9 j-m
G89	3.6 jk	3.6 g-j	3.5 j-n	3.5 i-l	3.6 j-m	3.8 g-k	4.0 ghi	4.2 i-l	4.1 l-o	4.2 ijk	4.2 f-i	4.4 g-j
G90	3.7 h-k	3.7 ghi	3.6 i-l	3.7 g-j	3.9 ghi	4.0 e-h	4.0 efg	4.4 h-k	4.6 i-l	4.6 f-i	4.8 ef	5.3 ef
G91	4.2 cde	4.1 d	4.1 def	4.1 def	4.4 def	4.7 cd	5.1 cd	5.7 cde	5.7 c-f	5.1 def	5.8 bcd	6.3 cd
G92	4.0 d-g	4.0 def	3.9 e-h	3.9 fg	4.0 gh	4.1 efg	4.3 efg	4.9 gh	4.8 h-k	4.8 e-h	5.2 de	5.1 efg
G93	4.1 d-g	4.0 de	4.0 d-g	3.9 fgh	3.9 ghi	3.9 f-i	3.9 ghi	4.4 hij	4.4 j-m	4.4 g-j	4.6 e-i	4.9 f-i
G94	4.3 cd	4.4 bc	4.4 abc	4.8 a	4.7 bcd	4.8 cd	5.1 cd	5.5 def	5.4 d-g	5.4 d	5.8 cd	5.8 de
G95	4.1 def	4.2 cd	4.2 cde	4.1 ef	4.1 fg	4.4 de	4.7 de	5.1 fg	5.0 g-j	5.2 de	5.6 d	5.7 de
G96	4.3 cde	4.1 d	4.1 def	4.3 cde	4.6 de	5.0 bc	5.3 bc	5.9 bcd	6.1 bc	6.3 ab	6.3 abc	6.6 bc

G97	3.9 e-h	4.0 def	3.9 f-i	3.9 fg	4.2 efg	4.3 def	4.6 def	5.2 efg	5.1 f-i	5.0 de	5.7 cd	6.2 cd
G98	4.1 def	4.2 d	4.2 cde	4.3 cde	4.4 def	4.7 cd	5.1 cd	5.8 cde	5.8 cde	6.0 b	6.3 abc	6.9 abc
G99	4.4 bc	4.4 bc	4.5 ab	4.5 abc	5.0 a	5.3 ab	5.8 ab	6.5 a	6.7 a	6.8 a	6.9 a	7.3 ab
G100	3.9 f-i	3.7 fgh	3.7 h-k	3.6 hij	3.6 j-m	3.7 g-l	3.9 g-j	4.2 i-l	4.3 k-n	4.4 ghi	4.9 ef	4.9 fgh
G101	3.8 g-j	3.8 efg	3.7 h-k	3.7 ghi	3.7 hij	3.9 ghi	4.1 fgh	4.6 ghi	4.4 j-m	4.4 g-j	4.7 efg	5.0 fg
G102	3.8 g-j	3.7 fgh	3.6 h-l	3.7 g-j	3.7 ijk	3.8 g-j	3.8 g-k	3.9 j-m	4.0 m-p	4.1 ijk	4.4 f-i	4.7 f-i
G103	3.5 klm	3.4 i-l	3.4 l-o	3.3 klm	3.5 j-m	3.7 g-l	3.9 g-j	3.9 j-m	3.9 m-p	4.0 ijk	4.2 f-i	4.2 h-k
G104	3.3 lm	3.3 kl	3.2 o	3.1 m	3.1 o	3.2 mn	3.3 kl	3.3 m	3.3 qr	3.3 m	3.3 k	3.5 klm
G105	3.3 m	3.3 kl	3.2 mno	3.2 lm	3.2 no	3.1 n	3.2 l	3.3 n	3.2 r	3.3 lm	3.4 jk	3.4 m
G106	3.5 klm	3.4 h-k	3.4 l-o	3.3 klm	3.3 l-o	3.3 k-n	3.4 jkl	3.4 mn	3.4 pqr	3.3 lm	3.4 jk	3.4 lm

G107	3.3 m	3.2 l	3.2 no	3.2 lm	3.5 mno	3.3 lmn	3.4 jkl	3.3 n	3.3 r	3.3 m	3.3 k	3.4 klm

[1] Means within a column followed by the same letter are not significantly different using the Waller-Duncan mean separation test (k-ratio = 100).

Table 6. Quality ratings (1-9, 9 = no disease symptoms) of 40 plants in experiment 5 testing the ability of three isolates of Rhizoctonia solani (RS4, RS5, and RS8) to induce disease in Colonial bentgrass germplasm. Each mean is an average of all three isolates.

GEN.	DAY 5	DAY 6	DAY 8	DAY 11	DAY 14	DAY 17	DAY 19	DAY 23	DAY 32
G108	3.6 f-l[1]	3.4 g-m	3.4 f-m	3.4 g-n	3.4 g-l	3.3 k-h	3.4 j-o	3.4 k-p	3.6 o-s
G109	3.5 g-n	3.4 g-n	3.4 g-m	3.4 h-n	3.4 g-l	3.4 h-m	3.5 g-n	3.6 h-o	4.0 j-q
G110	3.4 i-p	3.3 h-n	3.3 i-n	3.3 j-o	3.3 h-l	3.2 lmn	3.4 k-o	3.4 k-p	3.8 m-r

G111	4.1 bc	4.0 bc	3.9 bc	4.0 bc	4.1 bc	3.9 b-e	4.7 b	4.8 bc	5.3 bc
G112	3.2 op	3.1 mn	3.1 mn	3.1 no	3.1 jkl	3.1 mn	3.1 no	3.1 nop	3.3 rs
G113	3.3 l-p	3.2 k-n	3.3 h-n	3.3 i-o	3.3 h-l	3.4 h-m	3.4 h-o	3.5 j-p	3.9 l-q
G114	3.1 p	3.1 n	3.1 mn	3.0 o	3.1 l	3.0 h	3.0 p	3.0 p	3.1 s
G115	3.2 nop	3.2 lmn	3.1 lmn	3.1 mno	3.1 jkl	3.1 mn	3.3 l-o	3.3 nop	3.4 qrs
G116	3.7 e-i	3.6 d-h	3.6 d-i	3.6 e-i	3.6 d-h	3.7 c-i	3.9 d-h	4.0 d-j	4.4 e-l
G117	3.4 k-p	3.3 j-n	3.3 h-n	3.3 j-o	3.3 h-l	3.3 i-n	3.4 i-o	3.5 i-o	4.1 i-p
G118	3.6 f-l	3.5 e-k	3.5 e-j	3.5 f-k	3.5 f-i	3.4 h-m	3.4 h-o	3.6 h-o	4.3 f-n
G119	4.0 b-e	3.9 bcd	3.9 bcd	3.9 b-e	4.2 b	4.3 b	4.7 b	4.9 b	5.5 b
G120	3.7 e-j	3.6 d-i	3.6 d-i	3.5 f-k	3.4 g-l	3.4 h-m	3.5 g-o	3.6 h-o	3.8 m-r

G121	3.5 g-n	3.5 e-l	3.5 e-k	3.4 g-m	3.9 e-h	3.6 d-h	3.9 d-h	4.0 d-j	4.6 d-k
G122	3.7 f-k	3.6 d-h	3.6 d-h	3.6 e-i	3.6 d-h	3.8 c-g	3.8 e-j	3.9 f-k	4.3 f-n
G123	3.6 f-l	3.6 e-j	3.5 e-j	3.5 f-l	3.4 g-j	3.5 g-l	3.6 g-m	3.6 h-o	4.2 h-o
G124	3.4 h-p	3.4 g-n	3.4 f-m	3.4 g-n	3.3 h-l	3.4 h-m	3.5 g-o	3.6 g-m	4.1 i-o
G125	3.5 g-o	3.5 e-l	3.4 e-l	3.5 f-l	3.5 f-i	3.6 e-k	3.9 d-g	4.0 e-h	4.8 c-f
G126	3.3 nop	3.5 e-k	3.4 e-l	3.5 f-k	3.5 f-i	3.6 d-j	3.9 d-g	4.0 d-i	4.8 c-n
G127	3.4 h-p	3.4 g-m	3.4 g-m	3.4 g-n	3.4 g-l	3.4 h-m	3.4 i-o	3.4 k-p	3.9 l-r
G128	3.5 g-n	3.5 e-l	3.4 g-m	3.4 g-n	3.7 d-g	3.6 d-j	3.9 e-i	4.0 d-j	4.6 d-j
G129	3.2 op	3.2 lmn	3.2 k-n	3.2 l-o	3.4 g-l	3.2 lmn	3.3 l-o	3.4 l-p	3.8 m-r
G130	3.3 l-p	3.3 i-n	3.3 h-n	3.3 i-o	3.4 g-l	3.3 i-n	3.5 g-n	3.6 g-n	3.9 k-r

G131	3.6 f-m	3.5 f-l	3.4 e-l	3.5 f-l	3.5 fgh	3.4 i-n	3.5 g-n	3.7 g-n	4.4 f-m
G132	4.3 b	4.2 b	4.1 b	4.1 b	3.9 bcd	4.0 bc	4.5 bc	4.6 bc	5.1 bcd
G133	3.7 f-k	3.6 e-j	3.5 e-j	3.6 e-j	3.6 d-h	3.7 c-i	3.8 e-k	3.8 f-l	4.4 f-h
G134	3.3 l-p	3.3 i-n	3.2 j-n	3.3 k-o	3.1 i-l	3.2 lmn	3.1 mno	3.2 nop	3.5 p-s
G135	3.7 e-j	3.7 d-g	3.7 c-f	3.6 d-h	3.5 f-i	3.9 c-e	4.0 c-f	4.1 e-g	4.6 d-i
G136	5.1 a	4.9 a	4.9 a	5.0 a	5.2 a	5.4 a	6.4 a	6.8 a	7.2 a
G137	3.8 c-g	3.8 cde	3.8 cde	3.8 c-f	3.7 d-g	4.0 bcd	4.2 cde	4.3 c-f	5.0 b-e
G138	3.7 e-i	3.6 d-h	3.6 d-i	3.6 e-j	3.6 d-h	3.7 c-h	3.9 d-h	3.9 e-k	4.1 i-p
G139	3.6 f-m	3.5 e-k	3.4 f-l	3.4 g-m	3.5 f-i	3.5 f-l	3.6 f-l	3.8 f-l	4.2 g-o
G140	3.5 g-n	3.6 d-i	3.4 e-l	3.4 g-m	3.4 g-k	3.5 g-l	3.7 f-l	3.7 g-m	3.9 l-r

G141	3.4 j-p	3.3 h-n	3.3 h-n	3.3 h-o	3.3 h-l	3.3 j-n	3.4 i-o	3.7 g-m	4.0 j-q
G142	3.9 c-f	3.8 c-f	3.8 cde	3.8 c-f	3.9 b-e	4.0 bc	4.4 bc	4.4 cd	4.8 c-g
G143	3.8 d-h	3.8 c-f	3.6 c-g	3.7 c-g	3.8 c-f	3.8 c-f	4.2 cde	4.4 cde	5.2 bcd
G144	4.1 bcd	4.0 bc	3.9 bc	3.9 bcd	3.9 b-e	4.0 bc	4.3 bcd	4.6 bc	4.9 b-f
G145	3.6 f-m	3.5 e-l	3.5 e-k	3.4 g-m	3.4 g-k	3.4 g-l	3.7 f-l	3.7 g-m	4.1 i-o
G146	3.5 g-n	3.5 e-k	3.4 e-k	3.4 g-m	3.4 g-l	3.4 i-n	3.6 f-l	3.6 g-m	3.9 l-r
G147	3.2 p	3.1 mn	3.1 mn	3.1 no	3.1 kl	3.1 mn	3.1 o	3.1 op	3.4 qrs

[1] Means within a column followed by the same letter are not significantly different using the Waller-Duncan mean separation test (k-ratio = 100).

Table 7. Quality ratings (1-9, 9 = no disease symptoms) of 42 plants in experiment 6 testing the ability of the three isolates of Rhizoctonia solani (RS4, RS5, and RS8) to induce disease in Colonial bentgrass germplasm. Each mean is an average of all three isolates.

GEN.	DAY 5	DAY 6	DAY 9	DAY 13	DAY 15	DAY 19	DAY 23	DAY 30	DAY 60
G148	4.3fgh[1]	4.2ghi	3.6i	3.6j	3.7i	3.9hi	4.2i	4.9g	5.8c
G149	4.1h	3.9i	3.3i	3.3j	3.4i	3.4i	3.5j	3.6h	3.9d
G150	5.3a	5.1a	6.3a	6.0a	6.9a	6.8a	7.1a	7.7ab	8.1a
G151	4.8bcd	4.8bc	5.4bc	5.5cd	5.6e-h	5.9d-g	6.2e-h	6.8f	7.1b
G152	4.4efg	4.3efg	4.9efg	4.9hi	5.7d-h	5.8fg	6.3e-h	7.2def	8.2a
G153	4.4efg	4.3efg	4.6gh	4.9ghi	5.4gh	5.6g	6.1h	7.4a-d	8.0a
G154	4.9bc	4.9abc	5.5bc	5.6bc	6.0b-e	6.5abc	6.9abc	7.4a-d	8.2a
G155	5.0b	4.9abc	4.8fg	5.1e-i	5.9b-f	6.1c-f	6.6b-e	7.5a-d	8.3a
G156	5.0b	4.8bc	5.0d-g	5.4cde	5.8c-g	6.4abc	6.8a-d	7.5a-d	8.3a
G157	4.5ef	4.5def	5.2cde	5.5cd	6.1bc	6.5ab	6.7a-d	7.4a-d	8.2a
G158	5.3a	5.1ab	5.7b	5.9ab	6.3b	6.4abc	6.6b-f	7.3cde	8.2a
G159	4.4efg	4.4efg	4.8fg	5.2d-h	5.4gh	5.9efg	6.2gh	7.2c-f	8.2a
G160	4.4e-g	4.2gh	4.4h	4.9hi	5.4h	5.8fg	6.3e-h	7.3cde	8.1a

G161	4.3fgh	4.1ghi	4.7gh	5.0f-i	5.4h	5.9d-g	6.2fgh	7.4bcd	8.3a
G162	4.3e-h	4.3e-h	5.2c-f	5.3c-f	6.0bcd	6.3bcd	6.5b-g	7.4a-d	8.1a
G163	4.0h	4.1hi	4.6gh	4.8hi	5.6e-h	5.8fg	6.2fgh	7.3c-f	8.1a
G164	4.6cde	4.5de	5.3cd	5.3c-f	6.0c-f	6.5abc	6.9ab	7.7ab	8.3a
G165	4.5def	4.4efg	4.8fg	5.1e-i	5.5efg	5.9efg	6.4d-h	7.5a-d	8.3a
G166	4.5def	4.7cd	5.5b	5.5cde	6.1bcd	6.8a	6.9abc	7.8a	8.3a
G167	4.3fgh	4.2fgh	4.8gh	4.8hi	5.4gh	6.3b-e	6.6b-f	7.6abc	8.0a
G168	4.2gh	4.1ghi	4.8gh	5.3c-f	6.1bcd	6.0e-g	6.5c-g	7.5a-d	8.3a
G169	4.1bcd	4.3ab	4.6c	5.2bc	6.1a	6.0bc	6.5bc	7.5ab	8.1ab
G170	4.2b	3.9d-f	3.9h	4.5de	5.1de	5.4fg	5.9e	7.2bc	8.3a
G171	4.2bc	4.0cd	3.3ijk	3.2h	3.2k	3.3j	3.3hi	3.4f	3.4e
G172	4.0e-g	4.0cd	3.3ijk	3.2h	3.2k	3.3j	3.3hi	3.4f	3.4e
G173	4.5a	4.3ab	4.4cde	4.4de	5.0de	5.6def	6.1de	7.2bc	8.3a
G174	4.6a	4.4a	5.3a	5.3ab	5.8b	6.4a	6.9a	7.8a	8.3a
G175	4.2bc	3.8fg	3.5i	3.4g	3.5j	3.7i	4.1g	4.7d	5.3c
G176	4.1bcd	4.0def	4.2efg	4.3e	4.5h	4.7h	5.5f	7.1c	8.3a

G177	4.1bcd	4.0cde	4.2efg	4.3e	4.9ef	5.7de	5.9e	7.3bc	7.7b
G178	4.2b	3.8efg	3.2jkl	3.4g	3.1k	3.1j	3.2hi	3.3fg	3.4e
G179	3.8gh	3.8fg	3.3ijk	3.1h	3.1k	3.1j	3.2hi	3.3fg	3.4e
G180	3.9fgh	3.8gh	3.0l	3.0h	3.0k	3.0j	3.0i	3.0g	3.0e
G181	4.7b-f	3.9d-f	3.1kl	3.1h	3.1k	3.2j	3.4h	3.8e	4.1d
G182	4.2b	4.2bc	4.3ef	4.6d	5.4c	6.1b	6.6bc	7.5ab	8.3a
G183	4.1b-e	4.0cde	3.4ij	3.8f	3.8i	3.2j	3.3hi	3.3fg	3.4e
G184	4.0d-f	4.0def	4.3de	4.7d	4.7fg	5.8cd	6.4cd	7.4bc	8.3a
G185	3.9e-h	3.9d-f	4.0gh	4.3e	4.6gh	5.4efg	6.0e	7.3bc	8.3a
G186	4.2bc	4.3ab	4.9b	5.4a	6.0a	6.6a	6.7ab	7.5ab	8.3a
G187	3.8h	3.6h	3.3jkl	3.1h	3.1k	3.0j	3.0i	3.0g	3.0e
G188	4.0efg	4.2b	4.4cde	4.6d	5.2cd	5.3g	6.0e	7.3bc	8.3a
G189	3.8h	3.9def	4.3fgh	4.3e	4.5h	5.3g	5.9e	7.3bc	7.9ab

[1] Means within a column followed by the same letter are not significantly different using the Waller-Duncan mean separation test (k-ratio = 100).

Table 8. Quality ratings (1-9, 9 = no disease symptoms) of 24 plants in experiment 7 testing the ability of three isolates of Rhizoctonia solani (RS4, RS5, and RS8) to induce disease in Colonial bentgrass germplasm. Each mean is an average of all three isolates.

GEN.	DAY 5	DAY 6	DAY 8	DAY 10	DAY 12	DAY 15	DAY 19	DAY 28	DAY 57
G190	5.3a[1]	5.2a	6.1a	6.2a	6.3abc	6.4ab	7.1ab	7.9a-d	8.7a
G191	4.0hi	3.9hi	3.4h	3.4jk	3.4g	3.5i	3.7ij	4.0jk	4.3fg
G192	3.8i	3.7ijk	3.4h	3.4k	3.4g	3.5i	3.7ij	4.0jk	4.3fg
G193	4.2gh	4.0f-i	3.6h	3.6jk	3.6g	3.8i	4.1i	4.6i	5.1e
G194	4.9bcd	4.8bcd	4.3def	4.3h	4.3f	4.5h	4.9h	5.8h	6.9Dd
G195	4.4fg	4.3fg	4.6def	5.3de	6.4ab	6.4ab	7.1ab	7.9a-d	8.7a
G196	4.6ef	4.2fgh	4.6d	5.1ef	5.8cd	5.9b-e	6.6bcd	7.6a-e	8.5ab
G197	4.1h	4.0g-i	4.1efg	4.6f	4.6f	4.7gh	5.1hi	5.8h	6.8d
G198	4.9cd	4.6de	5.1c	5.5cde	6.2abc	6.3abc	6.8bc	7.4b-f	8.4ab
G199	5.3a	5.1a	5.6b	5.9abc	6.3abc	6.3abc	6.8bc	7.6a-e	8.4ab
G200	4.0hi	3.8ij	4.0fg	4.2hi	4.5f	4.7h	5.3gh	6.5g	7.6c
G201	3.6j	3.3l	3.4h	3.4k	3.4g	3.4i	3.5j	3.7k	3.9g
G202	5.4a	5.3a	3.3bc	6.0ab	6.6a	6.6a	7.4a	7.9abc	8.7a

G203	4.2gh	4.2fgh	4.4def	4.7fg	5.1e	5.2fg	5.9ef	6.9fg	7.9bc
G204	4.4fg	4.3ef	4.5d	4.8f	5.3e	5.5ef	6.2de	7.3def	8.3abc
G205	5.1abc	5.2a	5.7ab	5.7bcd	6.0bc	6.0bcd	6.8bc	7.9abc	8.8a
G206	5.2ab	5.1ab	5.6b	5.9ab	6.3abc	6.3abc	7.1ab	8.0ab	8.5ab
G207	4.8de	4.6de	5.6b	5.9ab	6.3abc	6.3abc	7.1ab	8.0a	8.5ab
G208	3.7j	3.6jkl	3.4h	3.6jk	3.7g	3.7i	4.0ij	4.4ij	4.8ef
G209	3.7j	3.6jkl	3.4h	3.5jk	3.6g	3.7i	4.0ij	4.6i	5.0ef
G210	5.1abc	5.0abc	5.1c	5.4de	5.9cd	6.1bcd	6.8bcd	7.5a-e	8.3ab
G211	4.4fg	4.2fgh	4.4de	4.9f	5.5de	5.8cde	6.4cd	7.4c-f	8.4ab
G212	3.6j	3.5kl	3.7gh	3.8ij	4.4f	4.8gh	5.6fg	7.3ef	8.4ab
G213	4.8de	4.7cd	4.5d	4.9f	5.5de	5.6def	6.3cde	7.6a-e	8.5ab

[1] Means within a column followed by the same letter are not significantly different using the Waller-Duncan mean separation test (k-ratio = 100).

Table 9. Quality ratings (1-9, 9 = no disease symptoms) of 64 plants in experiment 8 testing the ability of three isolates of Rhizoctonia solani (RS4, RS5, and RS8) to induce disease in Colonial bentgrass germplasm. Each mean is an average of all three isolates.

GEN.	DAY 5	DAY 6	DAY 7	DAY 8	DAY 12	DAY 14	DAY 20	DAY 22	DAY 30	DAY 37
G214	3.8 a-f[1]	3.5 d-g	3.4 k	3.4 j	3.6 g	3.8 h	4.0 l	4.3 m	4.6 l	5.1 m
G215	3.9 a-d	3.5 d-g	3.5 g-k	3.6 ghi	3.7 fg	4.0 efg	4.6 e-j	4.9 jkl	5.4 f-i	6.1 d-j
G216	3.6 g-l	3.5 d-g	3.8 b-g	3.8 c-g	4.0 a-d	4.0 c-g	4.7 c-h	4.8 l	5.1 jk	5.7 kl
G217	3.7 d-i	3.4 efg	3.4 jk	3.4 ij	3.9 c-g	3.8 gh	4.3 kl	4.9 kl	5.3 ijk	5.7 jk;
G218	4.0 a	3.8 ab	3.8 b-e	4.0 bc	4.1 a	4.3 ab	4.7 c-h	5.1 e-j	5.4 e-i	6.2 c-i
G219	3.7 e-i	3.8 ab	3.9 abc	3.8 c-g	4.1 abc	4.1 b-f	4.8 b-g	5.3 c-f	5.6 d-h	6.1 d-j
G220	3.8 a-f	3.6 b-f	3.6 e-j	3.7 ghi	3.8 efg	4.0 c-g	4.7 e-j	4.9 i-l	5.5 e-i	6.2 c-h

G221	3.6 h-k	3.6 b-e	3.8 b-g	3.8 d-h	3.9 c-g	4.2 a-e	4.8 a-e	4.8 l	5.4 f-i	6.3 c-g
G222	4.0 abc	3.7 abc	3.8 b-f	3.8 c-g	3.9 c-g	4.1 b-f	4.7 f-j	4.9 kl	5.3 ijk	6.1 c-i
G223	3.8 b-g	3.6 b-e	3.8 b-g	3.8 c-g	4.0 a-d	4.2 a-e	4.7 e-j	5.1 f-k	5.6 d-h	6.4 c-f
G224	3.9 a-e	3.9 a	4.1 a	4.1 ab	4.1 ab	4.3 a	5.0 ab	5.4 cde	5.7 b-e	6.4 a-d
G225	3.8 b-d	3.7 bcd	3.9 a-d	3.9 bcd	4.1 ab	4.2 a-d	4.8 a-f	5.4 cde	5.9 bc	6.8 ab
G226	3.6 f-k	3.6 b-e	3.8 b-e	3.9 b-e	3.9 a-e	4.1 b-f	4.9 a-d	5.3 c-f	5.6 c-g	6.3 c-f
G227	3.6 F-J	3.5 D-G	3.6 E-J	3.8 D-H	3.9 C-G	4.0 EFG	4.7 E-J	5.3 CDE	5.9 BC	6.8 AB
2228	3.4 jkl	3.4 fg	3.5 ijk	3.6 ghi	3.8 d-g	4.2 a-d	4.7 e-j	5.2 e-i	5.7 c-f	6.5 abc
G229	3.3 l	3.3 g	3.5 ijk	3.6 ghi	3.8 d-g	4.1 b-f	4.5 g-k	5.2 d-h	5.5 e-i	6.1 e-k
G230	3.6 f-j	3.5 d-g	3.5 h-k	3.8 c-g	4.1 ab	4.1 b-f	4.8 b-g	5.3 c-f	5.5 d-i	6.1 e-k

G231	3.7 d-i	3.5 c-g	3.5 h-k	3.7 e-h	3.9 a-e	4.1 a-e	4.6 e-j	5.3 c-f	5.4 ghi	5.9 g-l
G232	3.5 jkl	3.4 fg	3.4 jk	3.7 gh	4.0 a-d	4.0 c-g	4.5 h-k	4.9 kl	5.4 ghi	6.1 c-i
G233	3.9 abc	3.7 b-e	3.8 b-f	4.1 ab	4.1 a	4.1 a-e	4.6 e-j	5.3 cde	5.5 e-i	5.8 h-l
G234	3.8 a-f	3.6 b-e	3.8 b-e	3.7 fgh	3.8 d-g	4.1 a-e	4.4 jk	5.0 h-l	5.4 hij	6.2 c-i
G235	3.5 h-l	3.5 c-g	3.7 d-i	3.7 e-h	3.9 c-g	4.0 d-g	4.6 f-l	5.1 f-k	5.5 e-i	5.8 i-l
G236	3.8 c-h	3.7 abc	4.0 ab	4.0 bc	3.9 a-f	4.2 a-d	4.4 ijk	5.2 d-g	5.4 ghi	6.2 c-i
G237	3.9 abc	3.8 ab	4.1 a	4.3 a	4.0 a-d	4.2 abc	5.0 abc	5.3 c-f	5.6 d-h	6.2 c-i
G238	3.3 l	3.4 fg	3.4 jk	3.6 hij	3.8 d-g	4.1 a-e	4.8 d-g	5.4 bcd	5.9 bc	6.3 c-f
G239	3.5 i-l	3.6 b-f	3.8 b-g	3.9 b-e	4.1 abc	4.1 b-f	4.8 b-g	5.6 ab	5.9 bc	6.4 b-e
G240	3.4 kl	3.5 c-g	3.7 c-h	3.9 bcd	3.9 b-h	4.1 b-f	4.7 d-i	5.5 abc	5.8 bcd	6.1 e-k

G241	3.5 i-l	3.4 fg	3.6 f-k	3.8 c-g	4.0 a-e	3.9 fgh	4.3 k	5.0 g-l	5.1 k	5.6 l
G242	3.7 e-i	3.5 c-g	3.5 h-l	3.8 d-h	4.0 a-d	4.3 ab	4.8 a-f	5.4 cde	5.7 b-e	6.3 c-f
G243	4.0 ab	3.6 b-f	3.6 e-i	3.8 c-g	4.0 a-e	4.2 abc	4.7 d-i	5.2 d-g	5.6 c-h	6.3 c-f
G244	4.0 ab	3.7 abc	3.8 b-g	3.9 b-e	4.1 abc	4.3 ab	5.1 a	5.7 a	6.1 a	6.8 a
G245	3.9 a-e	3.7 bcd	3.7 c-h	3.9 bcd	4.0 a-d	4.0 c-g	4.6 e-j	5.3 c-f	5.5 e-i	6.2 c-h
G246	3.6 g-k	3.6 h-l	3.7 i-l	3.8 e-l	4.0 d-h	4.1 cde	4.7 c-i	4.9 klm	4.9 ln	5.4 m
G247	3.7 e-j	3.5 i-l	3.5 kl	3.6 lm	3.9 e-h	4.0 ef	4.6 g-k	4.9 jkl	5.1 klm	5.5 j-m
G248	3.9 c-g	3.7 e-j	3.7 g-l	3.6 klm	3.8 h	4.0 ef	4.5 h-m	5.0 g-k	5.6 c-g	6.2 c-f
G249	4.0 bcd	3.9 c-f	3.9 c-i	3.9 c-f	4.1 b-g	4.4 ab	4.7 e-i	5.3 b-e	5.6 c-g	6.1 def
G250	3.9 cde	3.9 c-f	4.0 b-f	4.0 b-f	4.2 a-d	4.4 a	5.1 a	5.4 abc	5.9 ab	6.4 bc

G251	4.3 a	4.0 a-d	4.0 d-f	4.1 a-d	4.1 b-g	4.3 abc	4.7 c-i	5.1 f-j	5.4 f-i	6.0 fgh
G252	4.3 ab	4.3 a	4.4 a	4.3 a	4.3 ab	4.4 a	4.9 a-d	5.4 abc	5.7 b-e	6.2 c-f
G253	4.2 ab	4.2 ab	4.2 abc	4.1 abc	4.2 a-d	4.3 a-d	4.9 a-f	5.4 a-d	5.6 c-g	6.0 fgh
G254	3.8 d-h	3.6 f-l	3.7 h-l	3.9 c-h	4.1 c-g	4.1 cde	4.6 g-k	5.2 d-h	5.4 ghi	6.0 f-i
G255	3.9 c-f	3.8 e-g	4.0 c-g	4.0 a-e	4.2 a-d	4.3 a-d	4.7 d-h	5.3 b-f	5.5 d-h	5.8 g-j
G256	3.9 c-f	3.9 b-e	4.0 b-e	4.0 c-g	4.1 b-f	4.3 abc	5.0 ab	5.4 ab	6.1 a	6.7 ab
G257	3.8 d-i	3.7 e-k	3.8 e-k	3.8 g-n	4.1 b-g	4.1 cde	4.6 h-l	5.1 f-j	5.4 ghi	6.0 f-i
G258	3.9 c-f	3.8 e-h	3.9 d-j	4.0 a-e	4.2 abc	4.3 a-d	4.9 a-d	5.1 e-i	5.8 bc	6.6 ab
G259	3.7 e-j	3.6 g-l	3.7 i-l	3.8 e-l	4.1 b-f	4.1 cde	4.4 j-l	4.9 jkl	5.5 e-i	6.1 efg
G260	3.7 f-j	3.8 e-h	4.1 bcd	4.0 a-e	4.2 a-d	4.3 abc	4.8 a-d	5.6 a	5.8 bc	6.4 bc

G261	4.1 abc	4.1 abc	4.3 ab	4.2 ab	4.4 a	4.3 a-e	4.7 c-i	5.3 b-f	5.4 ghi	5.7 k-l
G262	3.5 ijk	3.5 i-l	3.7 i-l	3.8 d-k	3.9 fgh	4.0 ef	4.3 klm	4.6 n	5.0 klm	5.9 h-k
G263	3.8 d-h	3.7 e-k	3.7 g-l	3.9 b-k	4.0 d-h	4.2 b-e	4.6 g-k	5.0 i-l	5.3 ijk	5.9 f-i
G264	3.8 d-h	3.6 f-l	3.7 i-l	3.9 d-j	3.9 e-h	4.1 cde	4.8 b-h	5.1 e-i	5.7 b-e	6.4 bc
G265	3.9 cde	3.8 e-i	3.8 e-k	3.9 c-h	4.2 a-e	4.1 cde	4.7 c-i	4.9 i-l	5.6 C-G	6.4 BC
G266	3.9 cde	3.7 e-j	3.8 e-k	3.9 b-j	4.0 b-h	4.1 cde	4.3 lm	4.9 jkl	5.4 ghi	6.1 ef
G267	3.6 h-k	3.5 i-l	3.6 kl	3.7 j-m	3.9 gh	4.0 ef	4.3 klm	4.9 jkl	5.3 hij	6.0 f-i
G268	3.7 f-j	3.7 e-k	3.8 f-k	3.9 d-k	4.1 b-g	4.1 def	4.5 i-m	4.6 n	5.0 klm	5.9 g-l
G269	3.5 ijk	3.4 l	3.6 kl	3.7 i-m	4.0 d-h	4.0 cde	4.6 e-j	5.1 e-i	5.6 c-g	6.3 cde
G270	3.4 k	3.4 kl	3.5 l	3.6 m	3.9 gh	3.9 f	4.3 klm	4.7 mn	4.9 m	5.4 klm

G271	3.5 ijk	3.4 kl	3.6 jkl	3.8 f-m	3.9 fgh	3.9 f	4.3 m	4.8 lmn	5.0 lm	5.4 lm
G272	3.5 jk	3.4 kl	3.5 kl	3.7 h-m	3.9 fgh	4.0 ef	4.3 c-i	5.1 e-i	5.6 c-g	6.4 bc
G273	3.7 e-j	3.7 e-k	3.8 e-k	3.9 c-i	4.1 b-g	4.1 cde	5.0 abc	5.2 c-g	5.7 bcd	6.6 ab
G274	4.0 bcd	3.9 c-f	3.9 c-h	3.9 c-i	4.2 a-d	4.1 cde	4.7 c-i	5.2 c-g	5.9 ab	6.8 a
G275	3.9 c-g	3.8 e-i	3.8 e-k	3.9 d-k	3.9 e-h	4.2 b-e	4.5 h-m	5.0 g-l	5.6 b-f	6.4 bc
G276	3.9 cde	3.8 efg	3.9 d-j	4.0 a-e	3.9 e-h	4.0 ef	4.0 d-h	5.3 b-e	5.6 b-f	6.4 bcd
G277	3.9 cde	3.9 b-e	3.9 c-h	4.1 a-d	4.0 c-g	4.1 cde	4.6 f-j	5.3 b-f	5.7 bcd	6.4 bc

[1] Means within a column followed by the same letter are not significantly different using the Waller-Duncan mean separation test (k-ratio = 100).

APPENDIX B. Colonial bentgrass genotypes used in large-scale brown patch screening.

G1 : BERGENPT LI 11
G2 : BERGENPT LI 7
G3 : PLATT BUR NE 3
G4 : URI 92-3 3
G5 : BERGENPT LI 15
G6 : BERGENPT LI 5
G7 : LAKEVIEW BRIDGEPORT 5-2
G8 : URI 92-28 1
G9 : BRANFORD CT CEM 7
G10: BERGENPT LI 9
G11: BRANFORD CT CEM 8
G12: 60 BR 16 03 2
G13: 1-1
G14: 31 BR 15 77 1
G15: 86 BR 16 27 1
G16: NEWPORT CC 106
G17: 86 BR 16 27 2
G18: CLEAR SM ZIPLOC 2
G19: 4 BR 15 64 1
G20: 53 BR 15 96 3
G21: 1-5
G22: 105 BR 12 96 5
G23: MEADOW EDGE LI 2
G24: 53 BR 15 96 4
G25: 1-4
G26: 1-2
G27: URI 92-29 1
G28: 60 BR 16 03 3
G29: 60 BR 16 03 4
G30: URI 92-11 2
G31: 15 BR 14 33 1
G32: TRINITY CEM PORTS MOUTH. R. 7
G33: URI 92-28 3
G34: 1-7
G35: 1-3
G36: 1-6
G37: 63 BR 16 06 1
G38: 63 BR 16 06 3
G39: MEADOW EDGE LI 20
G40: 31 BR 15 77 2
G41: 4 BR 15 64 2
G42: 53 BR 15 96 2
G43: 63 BR 16 06 4
G44: 53 BR 15 96 1
G45: 31 BR 15 77 3
G46: 63 BR 16 06 2
G47: 60 BR 16 03 1
G48: BRANFORD LI 3
G49: TOWN PARK OFF 84N LNDN CT 7
G50: NEWPORT CC 106
G51: BROOKFIELD CEM ON9 2
G52: NEWPOT CC 7
G53: TOWN PARK OFF 84N LNDN CT 4
G54: TOWN PARK OFF 84N LNDN CT 9
G55: TRINITY CEM PORTS MOUTH.R. 2
G56: TRINITY CEM PORTS MOUTH. R. 3
G57: TOWN PARK OFF 84N LNDN CT 2
G58: TOWN PARK OFF 84N LNDN CT 1
G59; TOWN PARK OFF 84N LNDN CT 8
G60: BP POLO 2ND 14
G61: TOWN PARK OFF 84N LNDN CT 15
G62: 84 BR 76 25 3
G63: NEWPORT CC 104
G64: TOWN PARK OFF 84N LNDN CT 5
G65: WOODSTOCK CT CEM 4
G66: TOWN PARK OFF 84N LNDN CT 6
G67: NOWPORT CC II
G68: NEWPORTCC I
G69: 84 BR 16 25 2
G70: LAKEVIEW CEM BRIDGEPORT 6-3
G71: TRINITY PORTS CEM MOUTH R.9
G72: 84 BR 16 25 4
G73: 4 BR 15 64 3
G74: 86 BR 16 27 1
G75: CEM WOODSHOLE 6
G76: WOODSTOCK CT CEM 1
G77: BROOKFIELD CEM ON9 4
G78: 86 BR 16 27 3
G79: 4 BR 15 64 1
G80: BP POLO 1ST 14
G81: 105 BR 12 96 9
G82: BERGENPT LI 17
G83: MT. GROVE CEM STRATPORT CT 6
G84: BP POLO 2ND 13
G85: EAST GREENWICH CC-POND 39
G86: URI 92-14 1
G87: BERGENPT LI 4
G88: NEWPORT CC 64

G89: URI 92-14 3
G90: LAKEVIEW BRIDGEPORT 5-1
G91: LAKEVIEW BRIDGEPORT 6-2
G92: LOFTS SEED BAG 2
G93; LOFTS SEED BAG 3
G94: 107 79 BR 157 6
G95: GREENVALE 1-8
G96: GREENVALE 1-4
G97: BERGENPT LI 6
G98: GREENVALE 2-4
G99: LAKEVIEW CEM BRIDGEPORT 5-3
G100: 2854
G101: 2841
G102; 2833
G103; URI 92-142
G104: 2856
G105: DARK GARBAGE BAG 4
G106: 2855
G107: 2840
G108: NEWPORT CC 20
G109: 2862
G110: 2827
G111: 2831
G112: 2839
G113; 2836
G114: 2834
G115: 2853
G116: 2849
G117: 2828
G118: 2850
G119: 2824
G120: 2860
G121: 2841
G122: 2853
G123; 2823
G124: 2933
G125: 2864
G126: 2869
G127: 2867
G128: 2830
G129: 2902
G130: UNKNOWN
G131: 2866
G132: 2852
G133: 2930
G134: 2942
G135: 2931
G136: URI 92-2
G137: 2935
G138: 2936
G139: 2943
G140: 2857
G141: 105 BR 12 '96 3
G142: 2905
G143: 2938
G144: 2922
G145: 2929
G146: 2928
G147: 105 BR 12 96 13
G148: NEWPORT CC 114
G149: 2904
G150: BERGENPT LI 5
G151: 2925
G152: BP POLO 1ST 23
G153: NORWICH CEM CANTER BURYTRAIC 3
G154: BRANFORD CT CEM 18
G155: LAKEVIEW BRIDGEPORT 5-2
G156: 7 BR 15 60 2
G157: 51 BR 15 94 3
G158: BRANFORD CT CEM 10
G159: GREENVALE 1-5
G160: 105 BR 12 96 5
G161: BERGENPT LI 9
G162: BRANFORD CT 11
G163: GREENVALE 2-1
G164: 105 BR 12 96 6
G165: GREENVALE 2-5
G166: BR
G167: NEWPORT CC 59-1
G168: 11 37 BR 144 5
G169: 29 BR 15 76 2
G170: 114 20 BR 157 4
G171: 79 BR 16 20 4
G172; 2937
G173: 79 BR 16 20 11
G174: GREENVALE 1-2
G175: 53 BR 13 96 4
G176: 105 BR 12 96 3
G177: 79 BR 16 20 1
G178: 105 BR 12 96 10
G179: URI 92-27 2
G180: 2848

G181: 2829
G182: BRANFORD CT CEM 1
G183: 2837
G184: EAST GREENWICH CC-POND 28
G185: EAST GREENWICH CC-POND 38
G186: NO TAG#1
G187: 2842
G188: GREENVALE 1-6
G189: NO TAG #2
G190: 105 BR 12 96 4
G191: 2859
G192: 2828
G193: 105 BR 12 96 6
G194: 2834
G195: 7 17 BR 14 3 4
G196: 31 BR 15 77 2
G197: 2832
G198: 63 BR 16 06 1
G199: BRANFORD CT CEM 13
G200: 105 BR 12 96 10
G201: 2926
G202: LAKEVIEW BRIDGEPORTS 6-3
G203: 13 44 BR 158 7
G204: BP POLO 1ST 10
G205: BERGENPT LI 3
G206: GREENVALE 2-6
G207: CAPE COD 7
G208: 2865
G209: 2847
G210: BERGENPT LI 1
G211: LAKEVIEW BRIDGEPORTS 6-1
G212: GREENVALE 2-2
G213: NO TAG #3
G214: 2835
G215: 2868
G216: BP POLO 2ND 19
G217: 2861
G218: 63 BR 16 06 4
G219: 2863
G220: NEWPORT CC 16
G221: 304
G222: 63 BR 16 06 4(?)
G223: 2932
G224: 2903
G225: 105 BR 12 96 7
G226: 105 BR 12 96 1
G227: 2843
G228: BP POLO 2ND 9
G229: 2858
G230: NEWPORT CC 29
G231: UNKNOWN
G232: 51 BR 15 94 5
G233: LOFTS SEED BAG 7-1
G234: HIGH FAIRWAY 9
G235: BERGENPT LI 4
G236: 63 BR 16 06 3
G237: 79 BR 16 20 2
G238: 53 BR 15 96 2
G239: 31 BR 15 77 3
G240: BP POLO 2ND 11
G241: 2846
G242: 2839
G243: GREENVALE 1-9
G244: 105 BR 15 94 2
G245: 51 BR 15 94 2
G246: BRANFORD CT CEM 12
G247: BRANFORD CT CEM 4
G248: BERGENPT LI 15
G249: NEWPORTCC 36
G150: 31 BR 15 77 1
G251: GREENVALE 1-7
G252: 105 BR 12 96 5
G253: 105 BR 12 96 11
G254: BRANFORD CT CEM 2
G255: BERGENPT LI 11
G256: NEWPORT CC 26
G257: BERGENPT LI 14
G258: 105 BR 12 96 8
G259: 29 BR 15 96 3
G260: 29 BR 15 76 1
G261: 15 BR 14 33 5
G262: BP POLO 2ND 18
G263: 29 BR 15 76 4
G264: GREENVALE 2-8
G265: 7 BR 15 66 1
G266: 105 BR 12 96 16
G267: NEWPORT CC 17
G268: EAST GREENWICH CC-POND 31
G269: 51 BR 15 94 4
G270: BP POLO 1ST 18
G271: BRANFORD CT CEM 14
G272: 7 BR 15 66 2

G273: 105 BR 12 96 12
G274: 105 BR 12 96 8
G275: 105 BR 12 96 7
G276: BERGENPT LI 8
G277: LOFTS SEED BAG 8