70 Years of Turfgrass Improvement at the New Jersey Agricultural Experiment Station

The Garden State's Rutgers University has long been in the forefront of turfgrass development.

by C. REED FUNK and WILLIAM A. MEYER

Rutgers University has a long lineage of researchers who have achieved prominent success. Five USGA Green Section Award winners have connections to the Rutgers program (clockwise from top): Dr. Glenn Burton (1965), Dr. Ralph Engel (1993), Dr. Reed Funk (1980), Dr. Richard Skogley (1992), and Dr. Howard Sprague (1974).

THE genetic improvement of turfgrass was initiated at Rutgers University by H. B. Sprague prior to the Second World War. Dr. Howard B. Sprague, the world-renowned agronomist at Rutgers, included turfgrass science as one of many areas of accomplishment and activity. He recruited Glenn Burton as a Ph.D. student to assist during the mid-1930s. Dr. Sprague believed that velvet bentgrass offered great potential for turfgrass improvement. It required little or no added fertilizer to produce a fine, dense, very attractive turf in shade or full sun, and at high or low mowing. He developed 'Raritan' velvet bentgrass, released in 1940. Turfgrass enthusiasts, including leading golf course superintendents, also cooperated with research personnel of the United States Golf Association and the United States Department of Agriculture at the Arlington Turf Gardens in northern Virginia. This resulted in the development of many vegetatively propagated creeping bentgrasses, 'Merion' Kentucky bluegrass, and 'Meyer' zoysiagrass. These productive programs were interrupted by the building of the Pentagon on the Arlington research facility property in 1942 and loss of key personnel to military service or critical jobs in support of the war effort.

Turfgrass extension, teaching, and research were re-established at Rutgers following the Second World War under the able and energetic leadership of Dr. Ralph Engel and later strengthened by the addition of Dr. Richard Skogley. Dr. Henry Indyk became Extension Specialist in Turfgrass when Dr. Skogley left to lead the Turfgrass Program at the University of Rhode Island. Each was convinced that significant opportunities existed in the development of improved turfgrasses. They and their turfgrass advisory committee recognized that more turfgrass, including home lawns, golf courses, sports fields, parks, institutional grounds, and road berms, existed within 100 miles of Rutgers than perhaps any other agricultural research institution in the world. They were aware that our major cool-season turfgrass species were introduced from higher latitude, maritime climates of the British Isles and northwest Europe. These grasses were not well adapted to the hot, humid summers, relatively cold winters, diseases, and insect pests of the mid-Atlantic and transition zones of the USA. This presented a real challenge to turfgrass managers but a great opportunity for genetic improvement. The administration of what is now Cook College agreed, and the turfgrass breeding position was offered in December 1961 to Reed Funk, a new Ph.D. with experience in breeding for salt tolerance at Utah State, alfalfa at Iowa State, and corn at Rutgers. It should be recognized that most turfgrass scientists at that time had received their graduate education in fields other than turfgrass. The startup funding and first year's budget was $400 and part-time use of a university car for germplasm collection. Fortunately, Dr. Ralph Engel provided additional support in turf maintenance. Drs. Engel, Indyk, and Felix Juska at the USDA, agronomists at the United States Golf Association Green Section, and seed growers in Oregon, Washington, and Idaho provided much needed and very useful advice and suggestions.

The turfgrass germplasm collection program started in 1962 has continued to the present with thousands of hours spent by turfgrass professionals examining tens of thousands of hectares of old turfs and heavily grazed pastures for elite turfgrass germplasm. Many single plants of Kentuck bluegrass, creeping bentgrass, dryland bentgrass, strong creeping red fescue, zoysiagrass, bermudagrass, and one clone of centipedegrass had persisted and spread to produce patches of turf as much as 25 meters in diameter. Single plants of perennial ryegrass, colonial bentgrass, velvet bentgrass, hard fescue, blue fescue, and Chewings fescue occasionally ranged from 1 meter to 4 meters in diameter. These rare plants came from the billions of seeds planted over past decades and contained genes for adaptation to their various environments. A unique, highly apomictic plant of Kentucky bluegrass has the possibility of being released as a new cultivar with most of its seeds producing plants genetically identical to the mother plant. Elite selections of creeping bentgrass, zoysiagrass, or bermudagrass can be propagated vegetatively to produce a new cultivar. However, plants of sexual, cross-pollinated species, including perennial ryegrass, tall fescue, fine fescues, rough bluegrass, and seed-propagated bentgrasses, zoysiagrasses, and bermudagrasses must be intercrossed with many other elite plants of their species to produce a useful cultivar. Normally, they must also be subjected to many years of population improvement to make them superior to turfgrasses already on the market.

Starting in 1962, a number of attractive plants of perennial ryegrass were found in old turfs near the sheep meadow in Central Park in New York City. Other interesting plants were found in Warinaco Park, Elizabeth, N.J.; Paterson Park and Riverside Park in Baltimore, Md.; the Colonia and Atlantic City golf courses; and the campus lawn of the University of Maryland, College Park, Md. Evaluation of selected plants in mowed clonal tests, spaced-plant nurseries, and disease screening tests and subsequently as single-plant progenies in closely mowed turf trials showed that the plants thriving in Central Park, New York City, had considerable promise. A synthetic of the 16 best performing plants was sent to other locations for testing.

It was soon apparent that 'Manhattan' had outstanding qualities compared to perennial ryegrasses in commercial use at that time and should be released. This required a decision by the New Jersey Agricultural Experiment Station as to the most appropriate method of making high quality seed of new turfgrass cultivars available to the public. After considerable discussion with leaders in the turfgrass industry, plant breeders at Rutgers and other universities, administrators, officials at the New Jersey Department of Agriculture, and seed certification personnel in New Jersey, Oregon, and Washington, we drafted a proposed release policy. A public meeting of interested parties was held on the turf trials at Rutgers, followed by indoor discussion. A number of useful comments and suggestions were made and incorporated, followed by a general agreement of the need for and advantages of restricted release. This would make it feasible for one or more commercial seed companies or groups of seed growers to invest their time, resources, and efforts in high quality seed increase by financing grower contracts with the most qualified farmers for seed production, maintaining seed inventories, promotion, and distribution throughout New Jersey, the USA, Canada, and, if appropriate, overseas. Rutgers would concentrate on research involving more effective breeding and evaluation techniques, germplasm collection and enhancement, and cultivar development.

With additional support from the United States Golf Association and a slowly increasing royalty stream, turfgrass breeding was gradually expanded. The New Jersey Agricultural Experiment Station also provided a technician in 1967. After Bill Siebels left, William K. Dickson accepted this position in September 1968. Ronald F. Bara was promoted to this position in October 1986, when Bill Dickson became Farm Supervisor at Horticultural Farm II.

We were all delighted to have Dr. William A. Meyer take over direction of turfgrass breeding in April 1996. He gave the program new energy, leadership, enthusiasm, and abilities. He has brought it to a new level of productivity and stature.

The labor supporting the Rutgers Turfgrass Breeding Program was provided by many individuals too numerous to name. More than 150 technicians, graduate students, administrative assistants, Rutgers faculty, and student employees have made countless contributions to the overall success of the program.

The effects of fungal endophytes in enhancing turfgrass performance and resistance to many harmful insects became apparent in the Rutgers University turfgrass field trials following research by Drs. Charles Bacon in Georgia and Ron Prestidge and associates in New Zealand. Scientists at Rutgers led and/or participated in studies that found that endophytic fungi are associated with many instances of enhanced turfgrass performance of perennial ryegrasses, tall fescues, Chewings fescues, hard fescues, blue fescues, and strong creeping red fescues. They showed an association between the presence of endophytic fungi and enhanced resistance to sod webworms, chinch bugs, and billbugs; improved summer performance and fall recovery; and resistance to crabgrass invasion in tall fescue and perennial ryegrass. They found that endophytic fungi were associated with resistance to chinch bugs and dollar spot disease in many species of fine fescues. They subsequently developed many useful perennial ryegrasses and fescues with endophyte-enhanced performance.

In order to continue Rutgers' leadership in endophyte research, Drs. Faith Belanger, James White, Qin Yue, Cecil Still, Thomas Gianfagna, Michael Richardson, and John Sacalis were hired or encouraged to do basic studies on endophyte biology and turfgrass-endophyte interactions. Assisted by a number of very capable graduate students and post-doctoral research scientists, these faculty members have made and continue to make many

The Rutgers turfgrass germplasm collection program started in 1962. Over time, tens of thousands of samples have been collected to include in the evaluation program. Biotechnology offers a new avenue for speeding up the improvement of turfgrass varieties.

Members of the Rutgers faculty share their expertise at annual field days held at the two main research farms. Turfgrass practitioners from all disciplines of the industry gather to learn about the latest research progress.

outstanding discoveries and contributions. Rutgers has the best and most productive program in the world on endophyte research in relation to turfgrass improvement.

Bentgrasses

Many golf courses and other fine turf areas developed during the late 1800s and the first few decades of the 1900s were seeded with fine fescues and South German mixed bentgrass. The latter was harvested from roadsides and non-tilled farmlands in central Europe and included varying percentages of colonial, creeping, dryland, and velvet bentgrasses. Recent collections from that region show that these bentgrasses were poorly adapted to New Jersey and other regions with hot, humid summers. It is apparent that only a few of the best plants survived to produce large patches of turf. The most attractive of the creeping bentgrasses were selected and evaluated by the USGA Green Section and USDA scientists and became the vegetatively propagated cultivars and much of the foundation of current breeding programs. Dr. Ralph Engel, with the assistance of Alexander Radko of the USGA Green Section, collected many promising creeping bentgrasses and established a large replicated test at Rutgers in October 1962. By this time, 'Penncross,' a three-clone synthetic developed at Penn State, was becoming widely accepted, reducing the need for vegetatively propagated bentgrasses. With financial support from Golf Course Superintendents Associations in New Jersey, Long Island, and the New York City metropolitan area, Professor Engel continued his lifelong interest in fine turf and his collection and evaluation program. USGA Green Section agronomists assisted in these germplasm collections, and their financial support helped provide assistantships for Phil Catron, Richard Rathjens, and Charles Kupat. The cultivars 'Cobra' (Engel *et al.*, 1994) and 'Viper' were developed from this program in cooperation with International Seeds, Inc. (now Cebeco International Seeds). As Dr. Engel was nearing retirement, Drs. Richard Hurley and Reed Funk initiated a new bentgrass improvement program directed primarily at cultivars useful on putting greens. They selected more than 1,000 creeping bentgrass plants from dozens of old golf courses in New Jersey, New York, Pennsylvania, California, and Arizona between 1981 and 1985. After clonal evaluation in New Jersey and Oregon, 203 plants were selected to produce 'Southshore' (Hurley *et al.*, 1990) released in 1992. 'Lofts L-93' was also developed from this program after extensive testing and population improvement.

The opportunity to substantially increase the bentgrass breeding program at Rutgers was one of the primary incentives used to attract Dr. William A. Meyer to New Jersey. He is assisted by Dr. Karen Plumley, Dr. James Murphy, Pieter den Haan, Stacy Bonos, Ronald Bara, William Dickson, and Dirk Smith. Bridget Meyer, Anita Szersen, and Gengyun Zhang also have assisted in germplasm collection. They are making excellent progress in the genetic improvement of velvet, creeping, and colonial bentgrass. Dr. Meyer and his team are also working with and assisting Drs. Faith Belanger, Barbara Zilinskas, and Tseh An Chen in their development of transgenic bentgrasses with herbicide resistance, stress tolerance, and disease resistance. The future is indeed bright for bentgrass breeding.

Turf-Type Perennial Ryegrasses

'Manhattan' (Funk *et al.*, 1969) was released in 1967 and proved to be a landmark cultivar that significantly enhanced the usefulness of perennial ryegrass for turf. Its success caused a number of plant breeding institutions throughout the world to redirect their programs to the development of improved turf-type ryegrasses. 'Manhattan' and other germplasm sources developed at Rutgers have been used in many breeding programs in North America and Europe. 'Manhattan' and the Kentucky bluegrass hybridization program gave considerable international recognition to the Rutgers program. It also convinced our administrators that the program was worthy of the support of a full-time technician and a graduate assistantship. 'Manhattan II' (Funk *et al.*, 1984) was developed jointly with Pure-Seed Testing and the Manhattan Ryegrass Growers Association. It was released in 1983 to replace 'Manhattan' in the USA. However, the excellent wear tolerance and winter performance of the original 'Manhattan' have encouraged managers of European soccer fields to continue its widespread use.

Continuing germplasm collection and population improvement programs at Rutgers and elsewhere have resulted in a continued stream of better performing cultivars widely used in North America, Europe, Japan, eastern Asia, and Australia. Seed production of turf-type ryegrasses in the USA exceeded 200 million pounds in the year 2000. With each new National Turfgrass Evaluation Program (NTEP) trial, the best performing cultivars of the previous test usually end up mostly on the second page of the new test only four or five years later. This documents the effectiveness of the continued population improvement programs. They involve many cycles of phenotypic and genotypic selection and population backcrossing. Each cycle of improvement builds on the achievements of all previous cycles in these cross-pollinated species.

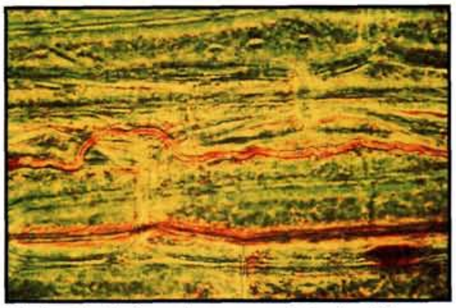
The occurrence of gray leafspot, a new disease on many ryegrass turfs, presents another challenge to turfgrass breeders. Fortunately, genes for resistance have been found in new germplasm collections made in eastern Europe by Dr. Meyer and his associates. These resistant plants have been crossed and backcrossed with the best plants from Rutgers and already combine good turf performance with genetic resistance to gray leafspot and other diseases.

Tall Fescue

Tall fescue is native to Europe and parts of Africa. It is best adapted to the hot, dry summer climates surrounding much of the Mediterranean Sea. The selection of 'Kentucky 31' and its release in the early 1940s initiated its widespread use throughout the warm, humid transition zone of the USA and the Mediterranean climates of California and Oregon. Natural selection of the best-adapted plants occurred over many decades on seed from Europe planted on a hillside pasture in Kentucky. Only plants able to survive the environmental stresses, diseases, and insect pests of this hot, humid location were able to produce multiple generations of seedlings. This concentrated the genetic factors for better adaptation to this new environment. Plants selected from this pasture were used as the parental germplasm of 'Kentucky 31.' It rapidly became widely used for reducing soil erosion, providing forage, and as a deep-rooted, heat-tolerant turfgrass.

Many turfgrass scientists recognized the useful qualities of tall fescue but also the need to overcome its limitations as a high quality turfgrass. An extensive germplasm collection effort covering many thousands of hectares of old turfs throughout the USA located a few attractive tall fescue plants that had persisted and spread to produce attractive turfs from 1 to more than 5 meters in diameter. Their appearance and the history of the turfs indicated that they likely originated from seed sources brought from Europe many decades earlier. After evaluation in mowed clonal trials and spaced-plant nurseries, the best performing plants were intercrossed and single-plant progenies were seeded in turf trials mowed at 2 cm. Plots of 'Kentucky 31' and other cultivars were unable to persist under these conditions of frequent close mowing and were soon replaced by weeds. The best appearing plants were then selected from the best surviving progenies to initiate another cycle of selection. Additional germplasm was added as it became available from the continuing collection effort. A few promising plants selected from tri-species hybrids of perennial ryegrass, meadow fescue, and tall fescue developed at the U.S. Regional Pasture Research Laboratory, University Park, Pa., were included.

'Rebel' tall fescue (Funk *et al.*, 1981) was released in 1980 following 18 years of plant selection and population improvement. 'Rebel' is considered a landmark cultivar, being the first of a new class of turf-type tall fescues with finer leaves, greater density, a slower rate of vertical growth, better shade tolerance, a brighter darker-green color, improved wear resistance, and greater persistence under close mowing. 'Rebel' and subsequent turf-type tall fescue cultivars and enhanced germplasms developed at Rutgers have contributed to most improved turf-type tall fescues on the market today.



Endophytic fungi are associated with enhanced turfgrass performance and improved turf resistance to harmful insects. Work at Rutgers University has focused on perennial ryegrass, tall fescues, and fine fescue performance.

Data from NTEP tests show continuing improvements in overall turf performance in tall fescue cultivars. Many new tall fescues are consistently outperforming cultivars available only four or five years earlier. A substantial percentage of these best performing new cultivars come directly from the Rutgers turfgrass breeding program and from companies working jointly with Rutgers (Table 1).

Fine Fescues

Fine fescues include strong creeping red, Chewings, hard, blue, and slender creeping fescues. As a group, they have fine, bristle-like leaves and the ability to produce a dense, fine-textured turf tolerant of medium-low soil fertility, moderately acid soils, moderate shade, tree root competition, and cold winters. They do not tolerate high nitrogen fertility, flooding, or poor drainage, especially during warm to hot weather. Continuing genetic improvements make each of these species more useful to homeowners and turfgrass professionals.

Professor Robert W. Duell and his students, including Richard Schmidt and Tony Palazzo, showed great interest in fine fescues and participated in the development of 'Banner' Chewings fescue (Duell *et al.*, 1976) released in 1985 and 'Fortress' strong creeping red fescue. Forty-five plants selected from old turfs in New Jersey, Maryland, Pennsylvania, and New York were used as the parents of 'Banner' after extensive clonal evaluation and progeny testing. Ongoing collection and population improvement are continuing to improve Chewings, hard, blue, and strong creeping red fescues. Cultivars developed by or with the participation of Rutgers continue to perform very well in NTEP tests (Table 1). Screening of large seedling populations under short-day-length, cool-temperature winter greenhouse conditions has been effective in selecting plants with greater disease resistance, higher tiller number, a slower rate of vertical leaf elongation, and a richer, brighter dark-green color. Similar results have been obtained in screening large seedling populations of tall fescue and perennial ryegrass.

Rough Bluegrass

Rough bluegrass (*Poa trivialis* L.) is adapted to cool, moist, shaded environments but rapidly becomes dormant in summer when subjected to heat and drought. Improved turf-type cultivars are often very useful for the winter overseeding of dormant warm-season turfgrasses in the southern USA and similar regions. However, this species is frequently a weed in many cool-season turfs in temperate climates. Drs. Henry Indyk and Ralph Engel collected a number of attractive plants from old turfs in New Jersey and surrounding states. William K. Dickson, a technician on the turfgrass breeding team, was eager to see if he could make a high quality turfgrass cultivar from these and other collections. Intercrosses of the best performing selections were subjected to cycles of phenotypic recurrent selection and produced the cultivar 'Sabre' (Dickson *et al.*, 1980) released in 1977. Sabre quickly became accepted in the winter overseeding market and eventually encouraged other turfgrass breeders to develop turf-type rough bluegrasses. Richard Hurley, studying for his Ph.D. degree at Rutgers, chose to work with rough bluegrass for his thesis project. A new, expanded germplasm collection and population improvement program resulted in the development of 'Laser' (Hurley *et al.*, 1990) and subsequently 'Winterplay' and 'Laser II.'

Kentucky Bluegrass

Kentucky bluegrass (*Poa pratensis* L.) is a major lawn-type turfgrass for much of the northern two-thirds of the USA and southern Canada. The land growing Kentucky bluegrass lawns has a higher real estate value than the land growing any of our major crop plants such as corn or soybeans! Its high and variable chromosome number ($2n=28$ to 153), its complex embryology, and its apomictic method of reproduction present great challenges and opportunities to plant breeders. Apomixis is a method of asexual reproduction in which nearly all seeds of a highly apomictic plant produce plants genetically identical to their maternal parent. Sperm nuclei from the pollen merely fertilize the polar nuclei to produce the endosperm. Apomixis is a nearly ideal method of producing a hybrid cultivar. It can retain maximum hybrid vigor through future cycles of seed increase and eliminates the disadvantages of vegetative propagation. The development and use of apomictic reproduction in major crops such as wheat, rice, soybeans, cotton, tree crops, and alfalfa would substantially increase world production of food, forage, and fiber.

Kentucky bluegrass has great genetic diversity and is naturalized throughout virtually all temperate regions of the world. The species includes germplasm with virtually every characteristic wanted in an ideal lawngrass. However, turfgrass breeders have yet to develop a rapid, efficient breeding method to recombine all of these characteristics into one interbreeding population or apomictic cultivar.

Currently, the Rutgers turfgrass breeding group is expanding its Kentucky bluegrass improvement program. Capable, energetic young scientists will produce both better cultivars and more effective breeding and evaluation techniques.

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This article was adapted with permission from an article with the same title in the Proceedings of the Tenth Annual Rutgers Turfgrass Symposium – 2001.

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Table 1
Top Performing Cultivars Developed with Participation of the Rutgers Turfgrass Breeding Program in Recent National Turfgrass Evaluation Program (NTEP) Tests

National Tall Fescue – 1992 – Final Report 1993-95 – 92 Entries	
*1. Jaguar 3	8. Coyote
3. Houndog V	9. Finelawn Petite
4. Genesis	10. Pixie
5. Pride	
National Tall Fescue – 1996 – Progress Report 1999 – 129 Entries	
1. Rembrandt	7. Coyote
2. Millennium	9. Shenandoah II
4. Plantation	10. Jaguar 3
5. Masterpiece	
National Perennial Ryegrass – 1994 – Final Report 1995-98 – 96 Entries	
1. Palmer III	4. Calypso II
2. Brightstar II	5. Premier II
3. Secretariat	7. Monterey
National Kentucky Bluegrass – 1995 – Progress Report 1999	
Medium-High Input – 103 Entries	*Low Input – 21 Entries*
1. Midnight	2. Eagleton
5. Princeton P-105	4. Caliber
	10. Dragon
National Bentgrass – 1993 – Final Report – 1994-97	
Putting Green – 28 Entries	*Fairway-Tee – 21 Entries*
1. L-93	4. Southshore
8. Southshore	
National Bentgrass – 1998 – Progress Report – 1999	
Putting Green – 29 Entries	*Fairway-Tee*
7. L-93	1. L-93
National Fineleaf Fescue Test – 1998 – Progress Report 1999 – 79 Entries	
Strong Creeping Red Fescues – 22 Entries	
1. Jasper II	6. ISI FRR-7
2. SRX-52961	7. ISI FRR-5
3. ABT-CR-2	8. PST-4FR
4. ABT-CR-3	9. Florentine
5. PST-EFL	10. Pathfinder
Chewings Fescues – 24 Entries	
1. Longfellow II	6. Treasure
2. Ambassador	8. Pick FRC A-93
3. ABT-CHW-3	9. Shadow II
4. ABT-CHW-2	10. Pick FRC 4-92
5. Intrigue	
Hard Fescues – 24 Entries	
1. 4001	6. Nordic
2. ABT-HF1	7. ABT-HF2
3. Oxford	9. ISI FL-12
4. SRX 3961	10. ISI FL-11

*Numbers refer to rank in turf quality averaged over all locations.