



# Development and Impact of Vegetative Propagation in Forage and Turf Bermudagrasses

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## ABSTRACT

The beauty and uniformity of vegetatively propagated grasses on golf course greens, fairways and tees, and on athletic fields and lawns and the superiority of the vegetatively propagated forage grasses that we enjoy today did not happen by accident. Risks were taken, innovative approaches were used, new equipment was developed and modified, and public institutions and private industry teamed up to make what we have today a reality. In the 1940s and 1950s, pioneering discoveries and advances were made in inventing equipment, establishing protocols, and developing consumer confidence. Vegetative reproduction in bermudagrass revolutionized the golf and athletic field industries by providing a superior, high-quality, uniform playing surface. It maximized profitability of the forage industry for cattle (*Bos taurus*) by providing the very best genotypes for farmers and ranchers to plant for grazing and hay. Although vegetative propagation of forage and turf started with *Cynodon* hybrids in a small area of the United States, the practice has expanded on a commercial scale to numerous species around the world.

Today, after years of research, development, and promotion, we enjoy the beauty of the high-quality ‘Tif’ or ‘Tifton’ (prefixes used to recognize the location where these cultivars were produced) pollen and seed sterile triploid interspecific hybrid turf bermudagrasses [*Cynodon dactylon* (L.) Pers. × *C. transvaalensis* Burtt-Davy] on golf courses, athletic fields, and lawns and the high yielding and high-quality vegetatively propagated forage hybrids (*C. dactylon*, *C. nlemfuënsis* Vanderyst and interspecific hybrids between these two species) in pastures and hay fields. However, back in the 1940s little was known about producing, planting, and managing hybrid bermudagrasses that produce little to no seed. From 1940, many discoveries and advances were made. Today, the vegetatively propagated forage and turf cultivars and associated enterprises account for a multibillion dollar business in the United States and around the world. The purpose of this article is to show how research and industry teamed up to develop the grasses and technology to make what we enjoy today possible.

## In the Beginning

Bermudagrass was introduced into the new world during colonial times and became an important pasture grass in the South by the late 19th century. James L. “Cowboy” Stevens was the first USDA-ARS forage agronomist in 1928 at the University of Georgia (UGA) Coastal Plain Experiment Station

(CPES) in Tifton, GA. He was responsible for the initial bermudagrass introduction nursery that formed the basis of forage improvement for bermudagrass. He discovered Tift bermudagrass in a cotton (*Gossypium hirsutum* L.) field near Tifton, GA, and his explorations and collection trips brought many valuable bermudagrass plant introductions from various parts of the world such as southern Africa and South America (Stephens, 1941). In 1936, when Glenn Burton, a USDA-ARS geneticist, came to the CPES, little if anything was known about breeding and improvement of bermudagrass for forage or turf. Until this time bermudagrass pastures were established from naturally occurring biotypes (Taliaferro et al., 2004).

## BREEDING BERMUDAGRASS FOR FORAGE

Burton noticed that bermudagrass plants growing along the railroad tracks were highly variable and concluded that this species probably reproduced by cross pollination. In 1937, Burton collected seed from Tift bermudagrass and two vigorous hay-type bermudagrasses from South Africa growing adjacent to each other in the introduction nursery. Hybrid seed was germinated in the greenhouse and 5000 spaced plants were established in 1938. Of the 147 plants selected from the 5000, selection number 35 was destined to become ‘Coastal’ bermudagrass (Burton, 1943). Silas Starr, then director of the CPES, felt number 35 should be named Coastal to recognize the experiment station where the hybrid was made and tested.

Coastal was very vigorous but set only a few seeds. In the testing process, it became evident that it may be possible to vegetatively propagate bermudagrass commercially. In 1942, one of Burton’s USDA-ARS bosses from Washington visited Tifton, GA, and saw common bermudagrass full of seed heads growing next to Coastal with no seed heads. Burton’s boss wanted to know how he planned to propagate Coastal. Burton

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**Abbreviations:** ADG, average daily gains; CPES, Coastal Plain Experiment Station; GCIA, Georgia Crop Improvement Association; LWG, liveweight gains; UGA, University of Georgia.

said, “vegetatively.” The USDA boss said, “whoever heard of planting pastures vegetatively!” Burton accepted the challenge to make vegetative propagation of forage practical. A wooden stick shaped like a putty knife on one end was first used to push sprigs (stolons and rhizomes) into the soil like planting sweet potato (*Impomea batatas* Lam.) vines. Later, a metal point was attached to the end of the stick. James Stephens, a UGA agricultural engineer at the CPES, developed a two-row planter. As more Coastal bermudagrass was planted, farmers became innovative and developed their own methods and machines.

### **An Industry is Born**

In about 1940, L.L. Patten (owner of Patten Seed Company), a seedsman, cattleman, innovator, legislator, and supporter of agricultural research, came by the CPES and saw Coastal. Patten wanted some of the grass and Starr convinced Burton that he should give a few Coastal bermudagrass sprigs to him even though the grass was not officially released. Patten took the grass to his Lakeland, GA, farm and vegetatively increased it to a 6.5-ha field, demonstrating the practicality of vegetative propagation. In the early 1940s, a few farmers showed interest in Coastal. Burton gave it away. Interest in Coastal continued to grow in the 1940s. However, not too much was said about distributing bermudagrass from the CPES to plant in fields, because bermudagrass was the worst weed cotton farmers had to contend with in their fields.

Bill Roquemore (son-in-law of L.L. Patten) said, “ranchers would come to Tifton with a gunny sack and a pitchfork, to dig a few sprigs.” In the late 1940s distribution in fertilizer bags and gunny sacks became too time-consuming and the Georgia Crop Improvement Association (GCIA) was formed with L.L. Patten as the second president. Today, the GCIA is a premier organization that inspects and ensures that growers receive pure planting materials for a number of agronomic crops, including the forage and turf bermudagrasses. After Patten became the first certified grower of Coastal, Burton started directing people to Patten as a source of a few free sprigs. As the demand for free sprigs increased, Patten decided he could buy some equipment to dig the sprigs, a hay rake to windrow the sprigs, then “pitchfork” them into people’s trucks and sell the sprigs cheaper than people could come with hired labor. Roquemore got “drafted into the seed and grass business” by Patten in 1947. By 1950, interest in Coastal was high and Patten built a brisk business in selling sprigs to cattlemen from the Carolinas to Texas and Oklahoma, mainly due to word of mouth and articles in the *Progressive Farmer* magazine. Patten would dig sprigs only on Monday so that he had time for his other farming operations the rest of the week. Roquemore remembered one Monday morning on arriving at work, there were 65 trucks from a half dozen states in a line stretching around the court house in Lakeland, GA, waiting to be loaded with 25 to 50 bushels of sprigs. Burton recalled that Patten came to him a number of years later and remarked, “you know, Burton, I made more money selling bermudagrass than anything I ever did in all of my farming operation.”

In the early 1950s, Roquemore felt there was money to be made delivering sprigs to farmers and got his wife’s grandfather to endorse a bank note to obtain enough money to buy a new truck and build a new bed on it. Roquemore started taking orders, and every 5 or 6 d would haul 1000 “honest” bushels

(0.035 m<sup>3</sup> per bushel) west to Texas, Oklahoma, Arkansas, and Louisiana. Being behind schedule, Roquemore remembered 1 d when 40 or 50 farmers were waiting at the courthouse in Coushatta, LA, at 2300 h for him to arrive with the Coastal sprigs. By the time he arrived with the sprigs, the farmers had already opened up a liquor jug and he felt that they wouldn’t have minded if he had arrived at 0200 h the next morning. To keep the sprigs from getting hot, Roquemore put 1.8 metric tonnes of ice on top of the load before heading west. The ice would melt during the trip and keep the grass cool. However, on one early spring trip to Texas, the ice melted and the entire load froze solid when they hit an unexpected cold front in Dallas. Roquemore said, “delivering Coastal sprigs out west put me on my feet financially.” By 1958, many counties from East Texas to Virginia had two or three farmers selling Coastal sprigs.

### **Advantages of Vegetative Propagation**

One of the major advantages of vegetative reproduction is that a single superior heterozygous genotype can be commercially utilized. Superior heterozygous genotypes can be crossed and a single superior genotype is ready for testing as a potential cultivar. Progeny testing is not necessary to establish genetic stability of the cultivar. Vegetatively propagated cultivars are morphologically uniform. This is especially appealing to the turf industry. It also has advantages in the forage industry because it is easier to stage plant growth for harvesting and/or grazing. Some may argue that a single genotype planted over a large area increases the risks of genetic vulnerability. It is a logical argument, but the authors are not aware of a single widespread problem with well-tested vegetatively propagated cultivar releases since Coastal.

### **Improving Forage Yield and Quality**

Coastal helped transform bermudagrass from the South’s worst weed in cultivated crops to a cultivar that is planted on over 4 million ha today. It produced twice as much dry matter as common bermudagrass (Burton, 1943) and revolutionized cattle and hay production in the southern United States. This cultivar has been a major factor in keeping beef and milk production profitable in the warm sandy Coastal Plain area of the United States for more than 50 yr. Burton and others worked on developing new and improved forage hybrids. ‘Midland’ was released (Harlan and Burton, 1954) as a more winterhardy cultivar than Coastal and is planted on 400,000 ha north of the Coastal Plain area (Burton, 1984).

Breeding for improved digestibility in warm-season grasses was a new concept in the 1960s. Animal scientist R.S. Lowery (UGA), agronomist W.G. Monson (USDA-ARS), and Burton first evaluated nutritional quality of experimental bermudagrass forage hybrids by using the in vivo “nylon-bag” technique. The laboratory studies were followed with numerous grazing and feeding trials, led by UGA animal scientists Phil Utley and Gary Hill, to evaluate the actual animal performance on the experimental hybrids. The data obtained from animal studies were key to the success in “selling” the new hybrids to farmers and ranchers. Initial work led to the development and release of ‘Coastcross-1’, which was 12% more digestible and gave 30 to 40% better average daily gains (ADG) and liveweight gains

(LWG) than Coastal (Burton, 1972). Now, most grass–forage breeding programs around the world use some type of forage quality–digestibility measure in cultivar development. Coastcross-1 was the first forage cultivar released based on improved digestibility. Though it was not winterhardy enough for most of the United States, it was planted on 200,000 ha in Cuba, where it produced more milk without supplement than any other grass tested (Burton, 1984). The latest cultivar, ‘Tifton 85’, may be the best bermudagrass cultivar since Coastal. It is a pentaploid sterile hybrid between a highly digestible released hexaploid, ‘Tifton 68’ (Burton and Monson, 1984) (developed from two *C. nlemfuënsis* lines), and a more winter hardy tetraploid *C. dactylon* plant introduction. In a 3-yr study, steers grazing Tifton 85 continuously from mid-April to mid-October averaged 0.67 kg d<sup>-1</sup> gain and 1135 kg ha<sup>-1</sup> LWG. It also produced 26% more dry matter that was 11% more digestible than Coastal (Burton et al., 1993).

Forage bermudagrass breeding programs have been established in Oklahoma, Florida, and Texas. Other important forage bermudagrass releases with more cold tolerance include ‘Tifton 44’ (Burton and Monson, 1978), ‘Guymon’ (Taliaferro et al., 1983), ‘Russell’ (Ball et al., 1996), ‘Grazer’ (Eichhorn et al., 1986), and ‘Midland 99’ (Taliaferro et al., 2002). Some stargrass varieties (primary *C. nlemfuënsis*) that have been released include ‘Florona’ (Mislevy et al., 1989) and ‘Florakirk’ (Mislevy et al., 1999).

### FROM FORAGE TO TURF

Coastal bermudagrass was a key “player” in the development of the turf industry. The first turf cultivar came out of the same group of hybrids from which Coastal was selected. The successful vegetative propagation of Coastal bermudagrass on a commercial scale was a stimulus for a number of turf species. Not only was vegetative propagation a breakthrough for pasture grasses, it also allowed use of the high-quality male and female sterile *Cynodon dactylon* × *C. transvaalensis* triploid hybrids as turf grasses. Specialized equipment was developed for digging both sod and sprigs and for vegetatively propagating these turfgrasses. A large sod industry developed in the Tifton, GA, area and spread to other areas of the country utilizing hybrid turf bermudagrasses on golf courses, athletic fields, and lawns. Today, the technology is used in other vegetatively propagated species such as St. Augustinegrass [*Stenotaphrum secundatum* (Walt.) Kuntze], seashore paspalum (*Paspalum vaginatum* Swartz), zoysiagrass (*Zoysia* spp.), centipedegrass [*Eremochloa ophiuroides* (Munro) Hack.], and so forth.

The major improved bermudagrass turfgrasses released from 1950 to the 1960s were vegetatively propagated. ‘Tiflawn’ (Hein, 1953) was a tetraploid that did produce pollen and seed while ‘Tifgreen’ (Hein, 1961), ‘Tifway’ (Burton, 1966a), and ‘Tifdwarf’ (Burton, 1966b) were pollen and seed sterile triploid interspecific hybrids between *C. dactylon* and *C. transvaalensis*. The latter three hybrids revolutionized the high-quality warm-season turfgrass industry from the 1950s through the 1980s. In the 1990s the release of ‘TifSport’ (Hanna et al., 1997), ‘TifEagle’ (Hanna and Elsner, 1999), ‘Midlawn’ (Pair et al., 1994a), and ‘Midfield’ (Pair et al., 1994b) pushed turf quality and reliability to new levels and have quickly become the industry standards in their respective markets.

### Breeding Turf Bermudagrass

Fred Grau, from the U.S. Golf Association Green Section, came to Tifton, GA, in 1946 and gave Glenn Burton \$500 to develop and evaluate new grasses for golf courses. At that time common bermudagrass or carpetgrass [*Axonopus fissifolius* (Ruddi) Kuhlm.] was being used on fairways and tees, and common bermudagrass [overseeded with ryegrass (*Lolium* spp.) for winter and early spring] or sand was being used on greens where warm-season grasses were the basis for turf. The method of propagation was seeding. Bermudagrass turf research started in the south by testing some turf-types from the forage crossing program and plugs of common types sent from golf courses. Dan Halls, a student at Abraham Baldwin Agricultural College in Tifton, GA, was the first student to work on the turf project with Glenn Burton. By 1949, Tiflawn (tested as Tifton 57) was identified and released. Tiflawn was one of 12 surviving plants of 500 established before World War II from seed progeny of a semidwarf selected from the 5000 original plants established in 1937 (the same group of plants from which Coastal was selected). It was a vegetatively propagated common type of bermudagrass with improved characteristics, but it grew too fast and produced too much thatch for greens. However, Tiflawn had potential for use on golf course fairways and on athletic fields. By 1951, Ray Jensen (a pioneer in the marketing of the improved turf bermudagrasses) and B.P. Robinson had a large plot of Tiflawn increased on some private land. In that year, O.B. Smith, groundskeeper for the Brooklyn Dodgers in Vero Beach, FL, heard about Tiflawn and wanted to plant it on the team’s field. Jensen and Robinson shipped bags of stolons to Smith to establish the baseball field. This was probably the first athletic field planted to an improved turf-type bermudagrass. Jensen said, “the sale of grass for the Brooklyn Dodgers field provided the capital to advertise and really advanced the improved turf bermudagrasses.”

In the 1950s, the market for vegetatively propagated grasses was limited on golf courses because superintendents were not familiar with planting sprigs and were not interested in the labor and management needed to plant sprigs. Jensen felt this could be solved by planting the grasses under contract on the golf courses. He was right. In 1956, Jensen contracted with the Fernadina Beach Golf Course to plant their entire course to Tiflawn. He planted it with a tobacco (*Nicotiana tabacum* L.) transplanter. The following year Jensen planted a par 3 golf course for George Jenkins, the founder of Publix grocery stores. It was at this point that Jensen decided that a better way than the tobacco transplanter was needed. Hans Schmeisser, a greens superintendent in south Florida, described to Jensen a straight disk embedding machine he had seen. A number of people experimented with building a straight disk planter for Jensen, but Omega Steel Works in Omega, GA, under Jensen’s supervision, built a transplanter that worked. The same basic unit, modified and automated, is still used today. Demand required that machines be developed for digging, planting, and fumigation. They could not be bought; they had to be invented. Some of the same machines built and patented are still being used today.

Tifgreen was released in 1956. Tifgreen came from a cross between an Egyptian *C. transvaalensis* introduction and a common bermudagrass from a golf course green on a country club

in North Carolina. It was the first improved commercial triploid interspecific hybrid bermudagrass to be released and could be mowed daily at a 4.7-mm plant height. Tifgreen received a large amount of testing on golf course greens, which contributed to its success. Interest in Tifgreen rapidly grew because it represented a major improvement and breakthrough in turf quality and was a sensational new putting green grass. Suddenly, there was a great demand for Tifgreen and everyone wanted to renovate their common bermudagrass greens. Roquemore said, "it was easy to sell Tifgreen to golf courses—actually it sold itself." In 1960, Jensen looked at a map of the southeast showing the location of golf courses and remarked to his wife, "we have planted Tifgreen on all of these courses, this has got to be the end." But it wasn't the end; there was a boom in developing new golf courses. By 1968, 12 yr after its release, Roquemore had planted more than 8000 greens to Tifgreen.

The release of Tifway in 1960 opened the opportunity to vegetatively plant up to 50 ha per 18-hole golf course of fairways, tees, and roughs. This provided a tremendous market not only for the grass but for subcontractors and machines to plant and maintain the grass. Tifway continues to perform well today.

In the 1950s and 1960s, numerous agronomic and management studies on mowing heights, fertility levels, fertilizer types, and so forth were conducted to find the best way to manage these grasses. This information was transferred to the field situation by industry and was essential for establishing and maintaining healthy grass.

In 1965 the release of Tifdwarf, which could be mowed daily at a 4-mm height, was another major improvement for putting greens and soon replaced Tifgreen. Tifgreen, Tifway, and Tifdwarf were the standards for many years for high-quality bermudagrass turf in the tropics and subtropics. The release of 'Tifton 10' provided a bluish-green hexaploid cultivar with improved cold resistance and color for use on golf course roughs and fairways, athletic fields, and in landscaping (Hanna et al., 1990). More recently, the release of TifSport with improved cold resistance and density, and TifEagle, an ultradwarf that can be mowed daily at 3 mm or less, are beginning to replace Tifway and Tifdwarf, respectively.

### Promotion and Advertising

Southern Turf Nursery became a subsidiary of Patten Seed Company in 1954 as a joint venture between Patten, Jensen, and Roquemore. It was the first company to promote the improved bermudagrasses for golf course use. A brisk business was developed selling and planting the vegetatively propagated bermudagrasses. In 1959 Patten Seed Company and Southern Turf Nurseries became separate companies operated by Roquemore and Jensen, respectively.

Marketing has been important. Roquemore and Jensen traveled thousands of miles by car and private plane across the south and southeast selling the improved vegetatively propagated grasses. Articles in newspapers and magazines were helpful in providing information and benefits of the new grasses. Thousands of two-bushel bags of grass were sold. Patten shipped thousands of two-bushel bags of grass sprigs to customers of the Sears and Roebuck Company and other garden stores. Jensen used a national advertising agency and shipped one or two square feet of grass to homeowners. He remembered one

lady who ordered a square foot of grass in April and then wrote him in September wanting a refund because she "didn't feel like she had the energy to plant the grass." Jensen sent her the refund. President Eisenhower, Arnold Palmer, and television are just a few reasons why golf became so popular, which resulted in a demand for more golf courses and resulted in a larger market for the high-quality bermudagrasses.

### CONCLUSIONS

What we have in turf today did not just happen. It took hard work, cooperation, invention, risk, entrepreneurship, financing, promotion, and so on. It involved a major team effort between research and industry. When Burton was asked what impact Roquemore and Jensen had on the use of the improved turf and forage bermudagrasses, he replied, "Jensen and Roquemore made all the difference in the world. No question about that. If they had not done what they did, I doubt that the things that we did in grass breeding and research would ever have been very important."

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