SALT-TOLERANT SILT GRASS (PASPALUM VAGINATUM SW.)

JULIA F. MORTON

Morton Collectanea, University of Miami
Coral Gables

Abstract. **Silt grass occurs naturally on muddy seacoasts, in tidal marshes and brackish sandy regions of both hemispheres from Baja California, North Carolina and southern Spain southward. Erect or prostrate in habit, it has a tough, creeping rootstock and forms dense mats. It has been successfully domesticated in Australia, southern Florida and the West Indies and has been introduced into cultivation in Venezuela. Easy to propagate and fast-growing, it makes excellent turf and is an ideal lawn grass for subtropical and tropical areas where irrigation water has a salt content unfavorable for better-known grasses. In coastal pastures, it provides nourishing fodder. The dried grass is employed as a tropical American folk remedy.**

Increased utilization of coastal areas—for residential, resort or purely recreational purposes, or for agriculture or grazing—as well as the mounting awareness of the need to control beach erosion, have intensified interest in salt-tolerant plants. In many regions, too, land that was formerly productive, and water sources formerly sweet, have acquired varying degrees of salinity, or brackishness, unfavorable to non-halophytic crops (28) or natural vegetation. Since all of these factors must be faced today in the development of tropical and subtropical lands, I want to bring to the attention of horticulturists and agronomists a multiple-use, salt-tolerant grass which I believe is worthy of greater exploitation, and the advantages and disadvantages of which should be fully explored.

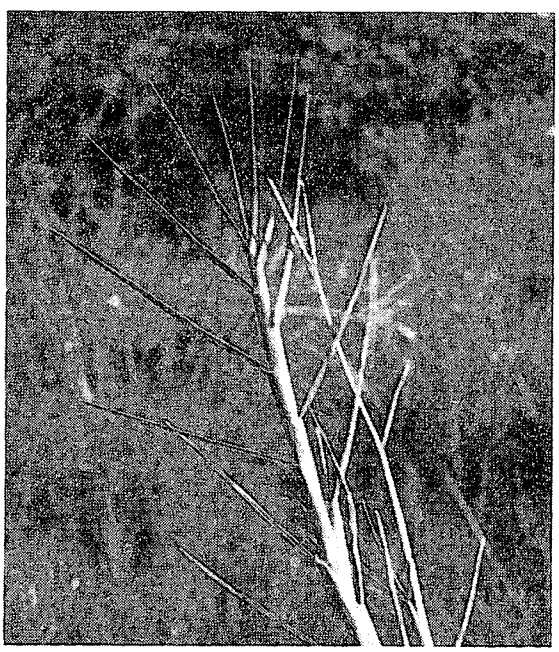

Fig. 1. Paspalum distichum L. in association with black mangrove (Avicennia) near San Juan, P.R. Note pair of erect racemes. Aug. 9, 1972.

Photo by Julia Morton

Identity and Nomenclature

Silt grass (11, 15, 18, 27), *Paspalum vaginatum* Swartz (syns. *P. littorale* R. Br., *P. distichum* var. *vaginatum* Swartz ex Griseb., *P. distichum* N. L. Burm., *P. distichum* F.-Vill., *P. inflatum* A. Rich., etc.), has been confused with jointgrass, or water couch-grass, *P. distichum* L., in the literature (15, 28, 55) and the two grasses may be found in similar situations. F. M. Bailey, writing of *P. distichum* L. "var. *normale*" and of *P. vaginatum* as *P. distichum* L. "var. *littorale*", in Queensland, stated: "These two varieties keep their distinctive characters when grown side by side on damp land, or near fresh-water swamps, but this latter thrives best and is always found in brackish swamps where the former cannot live." Hitchcock gives the habitat of *P. distichum* as "Ditches and wet, rarely brackish places" (20) and "Ditches and wet (some-

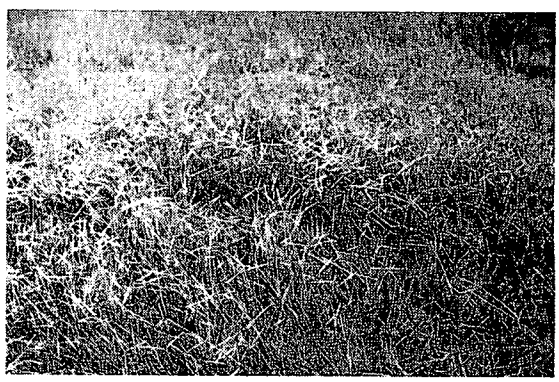

Fig. 2. Silt grass (Paspalum vaginatum Swartz) in seed. Sea Island, Ga. Sept. 12, 1973.

Photo by Julia Morton

Fig. 3. T. Miesse Baumgardner, Sea Island Golf Club. This site was source of all the silt grass distributed by O. J. Noer. Salt marsh in background.
Photo by Julia Morton

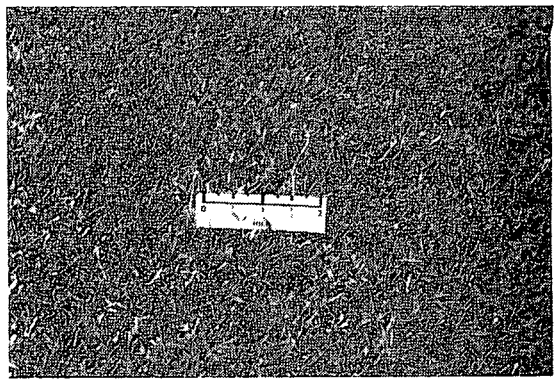

Fig. 5. Close view of silt grass, in seed, in putting green, Cloister Hotel, Sea Island, Ga. This green is mowed every 1½ days at 1/4-3/16 inch height.
Photo by Julia Morton

times brackish or alkaline) places" (19), but I have seen this grass flourishing in association with black mangrove (*Avicennia*) near San Juan, Puerto Rico, and on the borders of a salt marsh at Sea Island, Georgia. *P. distichum* usually attains greater height than silt grass, is hairy at the nodes, and its 2 (or sometimes 3) racemes remain erect and typically slightly curved inward toward each other, in contrast to the broadly divergent racemes of silt grass; also, the spikelets of *P. distichum* are plump and the second glume minutely pubescent (20).

Among the many vernacular names applied to silt grass are: seashore paspalum (29, 32, 33), sheathed paspalum (7, 8), salt jointgrass (51), seaside millet (18, 28), beschuitgras [biscuit grass] (52), grama (38, 42, 49), grama de mar, gramón and cambute, in Cuba (24), capim da praia, in Brazil (23), chépica, in Chile (40), chépica dulce or gramilla dulce, in Argentina (34), asinan, in Java (11), pagetpet and panluilui, in the Philippines (36).

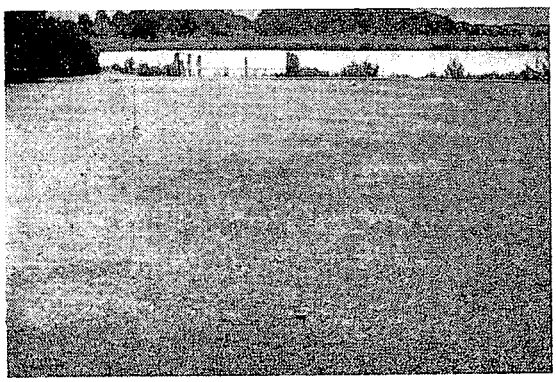

Fig. 4. Putting green, Cloister Hotel, Sea Island, Ga., with salt water frontage; originally planted to Bermuda (Tifton 328), now largely invaded by wild silt grass.
Photo by Julia Morton

Description

Paspalum vaginatum is a perennial, semi-aquatic, fast-growing, variable grass with creeping rootstock and creeping or floating stolons (runners), often red, on which the leaves are much reduced, the buds in their axils developing into new plants with crowded basal leaves; the plant ultimately forming a dense tuft which continues

Fig. 6. Fairway #8, Gulfstream golf course, Delray Beach, Fla. Silt grass, intermixed with Bermuda, has slightly broader, bluish-green blades which tend to lie flat.

to spread extensively by means of runners, these attaining lengths up to 3½ feet. Flowering culms are 3 to 24 inches high, solid; nodes and short internodes glabrous; sheaths loose, inflated, generally overlapping, more or less hairy at the mouth or glabrous; blades 1 to 2½ or as much as 6 inches long, 1/16 to 5/16 inch wide, semi-folded or flat, slanting upward or spreading at right angles, blue-green with a bloom on the upper surface, green beneath, firm, fleshy, juicy, with smooth margins. Racemes (summer to fall; Jan.-Apr. in South Africa) are spike-like, terminal, 1 to 3 inches long, initially upright but soon spread wide apart, even until horizontal; generally 2 racemes, sometimes 3 (3 not unusual in Panama), rarely 4 or 5. A single raceme is most unusual. Spikelets are 2-ranked, 3/16 inch long, less than half as wide, flattened, elliptic, acute; first glume usually undeveloped, second glume glabrous (1, 2, 7, 8, 20, 21, 25, 38, 43, 44, 49, 51, 52, 59).

Geographical Distribution and Regional Habitats

Paspalum vaginatum occurs wild on seacoasts of both hemispheres. Some botanists have considered it indigenous to the New World and introduced and naturalized in the Old. Its northern limits are reportedly Baja California, North Carolina, Bermuda and southern Spain, and it ranges southward into Chile, Argentina, southern Africa and Australia. In the United States, it is occasional in brackish marshes of the coastal plain of North Carolina, Georgia, Alabama, Mississippi, Louisiana, northeastern Texas and Florida (3, 20, 44, 59). J. K. Small collected this grass in Key West, Florida, in 1913. Florida specimens in addition to his in the Buswell Herbarium of the University of Miami are those of Baker (Gulf Coast of Hernando County, 1934), Buswell (coast of Miami, 1935) and Dickson (Big Pine Key, 1951).

The grass is commonly found in brackish marshes in Bermuda (7), on the edges of marshes in the Bahamas (New Providence, Watling's and Fortune Islands, Inagua (8) and Long Cay (21); in Cuba (provinces of Havana, Oriente, Las Villas and Pinar del Rio) (24); on the coasts of Jamaica, from whence it was first described (21); Haiti (Cape Haitien, Jacmel and the island of Tortuga); the Dominican Republic (at Higuey) (39). It grows in brackish soil at some points along the coasts of Puerto Rico and the offshore islands of Mona and Vieques (9); has been found on St. Croix (37) and Tortola in the Virgin Islands (9) and in Dominica (16); Martinique (21); in Barbados (at Crane Beach) (16); also in Trinidad and Tobago (21). It occurs in British Honduras, in the districts of Corozal and Belize (56); also on the Atlantic side of Costa Rica (53) and, in Panama, it has been collected on muddy shores at Colón, the Canal Zone and Panamá (54). It is very common along the coast of Venezuela (49) and Guyana; in Surinam (at Paramaribo, Warappacreek and on the Lower Surinam River); and in French Guiana (43); also along the shores of Brazil (23); and abounds in many coastal areas

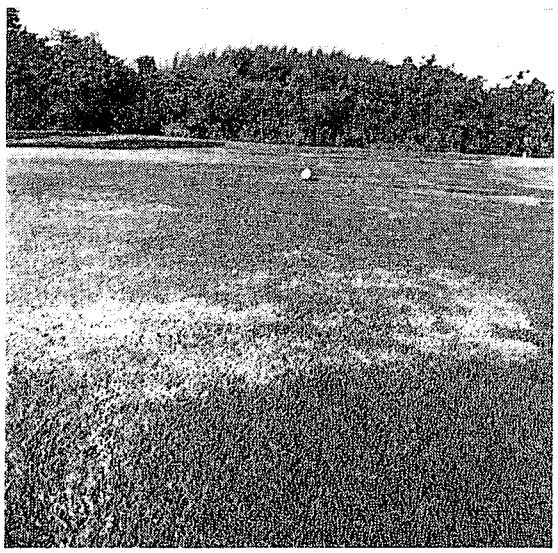

Fig. 7. Silt grass yellowed by herbicide; King's Bay Yacht and Country Club, Miami. Three weeks later was green, thinned out, but recovering.

Photo by Julia Morton

Fig. 8. Solid comfort on cushy silt grass lawn, Boca Patrick Estate, Curacao; a lush carpet in one year from cuttings.

Photo by Julia Morton

of Argentina. It was collected at Balao, Ecuador (19) and has been found at Callao and Lima, Peru (26). Chilean locations are not specified by Muñoz and Pizarro (40).

In West Africa, it is common near tidal swamps in Senegal and Sierra Leone "forming almost a turf in places" (14) and in Gabon (57). It is a dominant grass, often forming turf, on the flats of the Cape Peninsula in South Africa; and it flourishes in the maritime swamps of Mauritius (4), and on tidal flats and beaches of the Seychelles (46). Silt grass is abundant in saline mud around the Malay Peninsula; and in open wet lands, mainly brackish or salty, on the islands of Luzon, Panay and Samar in the Philippines *(36)*. In Java, Modoera and Halmahera, it is found throughout the north coastal plains, among mangroves, and in marshes, forming a solid stand in salty clay soils; also inland on open, silty ground around fish ponds and creeks (18) and around salt-wells (2). On sandy strands it assumes a different form and occurs in separate clumps (18). In Samoa it was collected on a sandy beach on the island of Upolu (13) and it has been observed growing sparingly on coral rock and on a sandy beach on the east coast of Peleliu in the Carolines (10). It inhabits brackish marshes and mangrove swamps of Guam (55). Abundant in Australia, it covers silt bordering ponds and rivers; is conspicuous in swamps and salt marshes in Queensland, New South Wales (28), Victoria (15) and Western Australia (28).

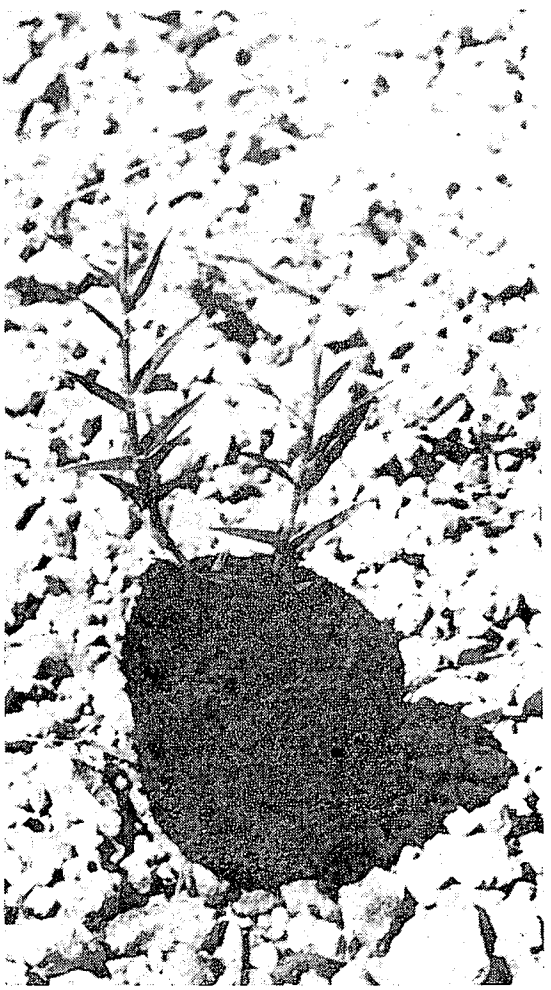

Fig. 9. Silt grass sprigs in Jiffy 7 pot, ready for planting, 12 per square meter, a practice found successful by H. J. Riese, Boca Patrick Estate, Curacao.

Photo by Julia Morton

Reputation and Economic Value

Enthusiasm for silt grass is most evident in reports from Australia. Malcolm and Laing declare that it "has an amazing ability to thrive in wet salty situations. Bogs, gullies and seepage areas which stay wet even with salty water during the summer are ideal situations for growing *Paspalum vaginatum*. It will form a dense mat of roots which stops erosion and reduces bogging . . ." (32). In Maiden's words, it is "exceptionally adapted to cover silt or bare slopes on banks of ponds and rivers, where it grows grandly; moderate submersion does not destroy it . . ." (28).

As a fodder grass, Maiden praised it, saying that it "produces in summer months a quantity of feed . . . horses and cattle eat it readily. It supplies valuable food for stock in localities where species of value are never abundantly found. It is beautifully green throughout the year, and offers a sufficiently tender blade for feed . . ." (28). Malcolm says that as a pasture grass *Paspalum vaginatum* could be grown on hundreds of acres of salty seepage areas throughout the agricultural districts of Western Australia . . . "Salty seepages occur throughout the agricultural areas due to the approach of percolating water to the surface". He recommends *Puccinellia* on the drier fringes of such areas and *Paspalum vaginatum* in the wet central sections. "When established, it is very resistant to grazing . . . it is virtually impossible to eat it out." However, "Until bare areas have been covered with grass it will benefit from grazing protection, since sheep crop the grass closely and stop runners colonising surrounding

bare soil." (30) Burkill, in Malaya, wrote: "Cattle eat it and fatten on it. On the whole, it is well spoken of." (11) In Africa, it is recorded as a good fodder grass (14, 57) and it is so regarded in Cuba (24). In Venezuela, it is one of the principal forage plants of the district of Paparo (42). Stone says that it is "a useful pasture grass in sumpy areas" of Guam (54). Shiflet reports that it rapidly invades and furnishes up to 95% of the forage in coastal marsh pastures of Louisiana for nearly 3 years after salt water inundation from storm tides (50). Heyne wrote, "In Java considered practical for cultivation only on silty-marshy terrain that is unfit for other purposes". "A useful, though not superior cattlefodder." "Noteworthy is the small amount of roughage, averaging only 30% (18). In Brazil it is regarded as "Mediocre forage, but eaten by cattle because of its salt content" (23). Stahel tells us that in Surinam silt grass grows along the roads and is often cut for cattlefeed even though it is much less important than Para grass (52). Elsewhere it is declared to be unfit for hay because of slow drying and the fact that it turns black and unsightly (18, 28).

In Australia, silt grass is recommended for lawns, especially in areas handicapped by soils or water too salty for the moderately salt-tolerant couch, or Bermuda, grass, *Cynodon dactylon* Pers., and buffalo grass, *Stenotaphrum americanum* Schrank. Malcolm and Laing say that good lawns can be grown with fresh water, also. "Growth in shaded areas is akin to couch and buffalo in winter but survival is better and the warm weather restores a continuous turf. It produces vigorous runners but it is not as aggressive in the garden as kikuyu" [*Pennisetum clandestinum* Hochst. ex Chiov.] (32). Under favorable conditions, it will escape from cultivation. Dalziel says that it is a troublesome weed on rice lands in Sierra Leone and difficult to eradicate (14). Two years ago, I received for identification a specimen of silt grass from southern Spain. It was reported as invading a golf course and advice was sought on methods of eradication.

In Cuba and Latin America, silt grass is valued in folk medicine. A decoction is widely advocated as a diuretic (24, 42), such action thought to be attributable to salts and glucosides (41). Manfred says that in cases of dropsy, swollen feet and kidney stones, the decoction gives magnificent relief. One handful of the root is boiled for 10 minutes in a liter of water and the patient takes several cups a day (34).

Temperature Sensitivity, Water Requirements and Salt Tolerance

Silt grass is limited to subtropical and tropical climates. Maiden wrote: ". . . frost injures it" (28). In regard to rainfall, Malcolm says the grass has no preference; the amount is "immaterial as growth depends on availability of seepage water in summer". "Although *Paspalum vaginatum* grows on saline watertable areas in high rainfall districts, most watertable areas are too dry or too salty . . ." This grass needs abundant moisture and survives flooding (30). Shiflet believes that it needs water above the surface to compete with other species (50).

In saline regions of Australia, common salt (sodium chloride) may constitute 75% or more of the total salts in the soil or water. Magnesium is an insignificant factor. In cultivation for pastures or for lawns, Malcolm and Smith have found that *Paspalum vaginatum* can tolerate irrigation water containing 3,500-13,000 mg of total soluble salts per litre (245-910 grains per gal, or 5,500-20,300 electrical conductivity in micromhos per cm at 25° C.) (33). In testing the salt content of the soil solution in the root zone of *Paspalum vaginatum* in summer, Malcolm found 0.31 to 2.08% NaCl at a depth of 0.5 cm. (31).

Propagation and Culture in Australia

Recommended planting time in Australia is spring [August-September in Western Australia] to allow establishment before summer, though mid-summer planting is successful in very wet seepage areas. "Under the most favourable conditions one small piece of root may spread to cover an area five feet in diameter by the end of autumn" (32). Roots may be started in nursery plots and transplanted. Crusty surfaces of planting sites should be first loosened up. In wet areas, runners will root if merely scattered on the surface but it is better to cover them and press the soil down firmly. In large, drier areas, bits of sod (2 or 3 inches square) are set in a ploughed furrow which is then partly covered by the plough and compressed by the wheels of the tractor, and a subsequent mulch of hay or straw is beneficial. Malcolm and Laing mention a successful lawn that was created by applying 6 inches of yellow sand over heavy gravelly clay soil and irrigated with water which, during the summer, varied between 530 and 650 grains per gallon of total soluble salts (7,600 to 9,300 ppm). The Department of Agricul-

ture of Western Australia furnishes runners from stands of *Paspalum vaginatum* which it maintains at its Avondale Research Station at Beverley. The seed is not available (32). Apparently seed has not been collected by botanists in Java (2, 18).

Performance in Golf Courses in the Southeastern United States

The late Mr. O. J. Noer, of the Sewerage Commission of the City of Milwaukee (producers of the fertilizer known as Milorganite) became keenly interested in *Paspalum vaginatum* which was called to his attention by Mr. T. Miesse Baumgardner at the Sea Island Golf Club, Sea Island, Georgia. There, silt grass occurs naturally along a saltwater marsh (the "Marshes of Glenn") where high tides flood the grass several times a year. It has spread over much of adjacent Fairway #13 originally planted with "ordinary" Bermuda grass. The fairway is low and underlaid with marl. Here, silt grass is easily distinguishable and healthier except at certain seasons when it shows more susceptibility to dollar spot than the Bermuda. Silt grass has also taken over much of the Practice Putting Green in front of the Club House. About 5 miles away is the Cloister Hotel where a putting green of approximately 15,000 square feet was planted with Bermuda (Tifton #328) about 10 years ago. The green has been largely invaded by silt grass, apparently because of overwatering for years by the hotel gardener. There is no weed problem here and no dollar spot because Milorganite is applied more frequently than on the fairway. Nearby the Hotel maintains a very good bowling green entirely of volunteered silt grass. Mr. Baumgardner says that silt grass makes an acceptable putting green if mowed every 1½ days at 1/4-3/16 inch height. However, in the fall it produces a heavy crop of seeds and it is primarily for this reason that it is eliminated when it appears in the putting greens on the Sea Island Golf Course.

At the Sea Island Gun Club, between the firing range and the marsh, there are some open areas on which silt grass occurs as individual clumps. None of the silt grass has been deliberately planted at the Sea Island Golf Club. A new "4th nine" is being developed on salty fill and planted with Bermuda #419, with a border of *Paspalum distichum* set out on the marsh side (6, 38).

The natural stand of silt grass adjacent to Fairway #13 has been the source of the various distributions of this grass made by Mr. Noer. The first was sent by mail to Vero Beach. *About 10* years ago, a block 2 feet square dug from this spot was taken by Mr. Noer to Hawaii where he was serving as consultant for Robert Trent Jones, Inc., in the development of the Mauna Kea Country Club (22). It was through Mr. Noer that silt grass reached the experimental plots of Dr. G. C. Horne, Ornamental Horticulture Department of the University of Florida at Gainesville. Planting material was supplied by Dr. Horne to Mr. Ralph White, then with the Ousley Sod Company, west of Deerfield (58). About 1961-2, the resulting sod was taken up by Verticutting which took up roots as well as stems and blades, and the entire stock of 240 bushels of shredded grass was purchased at $5 a bushel by Otto Schmeisser, then Greens Superintendent of the Gulfstream Golf Club, Delray Beach (now at the Indian Creek Country Club). The grass was planted to cover 1 acre of Fairway #8. Later, planting material was taken from this section and set out in Fairways #5 and #10. All of these fairways were originally planted to Bermuda. The replanted areas were sprayed with sodium arsenite and rototilled before the silt grass was installed. Competition between the two grasses fluctuates with the season. In the summer, Bermuda grass is the more aggressive. In winter, silt grass remains green and outgrows the Bermuda. During dry seasons, now mainly in spring, salt moves up to the surface of the soil and, while silt grass recedes somewhat because of drought (despite regular freshwater irrigation), it is less affected than Bermuda because of its greater salt tolerance. After one hurricane, when dike water overflowed, the golf course was flooded with salt water for 2 days before it was completely pumped off. Bermuda grass, which can tolerate no more than 1,200 ppm chlorides, was severely affected but the silt grass remained green and flourishing.

Mr. Otto Schmeisser's principal complaint concerning silt grass is its sensitivity to herbicides—usually DSMA or MSMA (monosodium methyl arsenite) (48). His father, Mr. Hans Schmeisser, is currently serving as consultant at Gulfstream. On August 30, he and Mr. Stanley Carr, present Superintendent, showed me the mixed silt grass-Bermuda areas of the fairways. On close examination, the silt grass can be distinguished from the finer, erect blades of Bermuda by its slightly broader, bluish-green leaves which tend to lie flat.

Mr. Ralph White, who now represents Southern Turf Nurseries at Eustis, Florida, says that he gave up efforts to raise silt grass commercially be-

cause of disease problems and its sensitivity to herbicides (58). This disenchantment may be the result of growing silt grass in non-saline conditions. Dr. Evert O. Burt, Turf Specialist at the University of Florida's Agricultural Research Center in Ft. Lauderdale, told me that he maintained *Paspalum vaginatum* in his home yard for 3 years. There were plenty of leafhoppers in evidence but caused no known damage. However, the grass finally succumbed to nematode infestation. In a saline location, nematodes would not have been present. Dr. Burt considers silt grass entirely suitable for coastal fairways (12).

My interest in silt grass began in mid-1969 when Charles Mahannah, Golf Course Architect, showed me a dense, carpetlike stretch of it on the tidewater perimeter of the golf course at the King's Bay Yacht and Country Club south of Miami. I was impressed when he told me that the tide washing over this grass doesn't harm it but rather makes it greener. His father, Mr. Mark Mahannah, Golf Course Architect at the Riviera Country Club, Coral Gables, received *Paspalum vaginatum* sod from Mr. O. J. Noer about 20 years ago and established it in experimental plots. It was later transplanted by father and son to a property on Miller Road where it spread to cover 1 acre. This plot served as the source of the material which was installed at King's Bay 15 years ago. Thereafter, the acre on Miller Road received no attention and the grass ultimately died out, perhaps because of nematodes since this site is free of salt influence (27).

Trial in Curacao

During several years of intermittent field work on the island of Curacao, Netherlands Antilles, I have been very much aware of the general lack of lawn grass and the brackishness of the water in most of the wells. It occurred to me that *Paspalum vaginatum* should be tried there. Charles Mahannah, at my request, planted a sod bed and, when it was well established in December 1969, presented to me 100 lbs of the sod (with soil attached) which I sent by air freight to Henry J. Riese, Managing Director, Boca Patrick Estate, on the coast near the village of Barber, Curacao. Mr. Riese planted the sod in 4 locations with 3 different levels of salinity. That which had maximum exposure to salt water failed to survive. The most successful patch was inland on clay in partial shade, received fertilization and two top dressings and benefitted from daily showers during an unusually rainy winter period. It was consequently hose-watered only once during the first 3 months. The well water at this location contains: Ca 137 mg/1; Mg 142 mg/1; chloride 22.0 meq/1; chloride as NaCl 1.52 g/1; HCO_2 520 mg/1; sodium 17 meq/1 or 392 mg/1; pH is 6.7. No diseases appeared but an invasion of army worms required control.

In midsummer of 1970, mowed trimmings from this sod were strewn over a prepared raised lawn area. They quickly took root and sent out runners in all directions, completely covering the ground in 2½ months. At the beginning of November, he declared this to be the finest lawn on the island of Curacao (45). When I photographed this lawn one year after planting, it was a lush, fine, rich-green carpet and it has remained in excellent condition to date—that is, for a period of over 3 years.

During the past year, Mr. Riese has installed two other silt grass lawns on the windward side of Spaanse Water, a nearly enclosed bay on the southeastern coast of Curacao. Planting material consisted of sprigs started in Jiffy 7 peat pots. Roots are well formed in 2 days. The pots were set in the ground 8 to 12 inches apart, or 12 per square meter. One thousand can be set out in a day. In 6 weeks, the grass spreads to form a light cover of the area. Full cover is attained in 8 to 12 weeks. In Mr. Riese's experience with the original lawn and these two installations, which are now 8 months of age, he has encountered no disease and no weed problems. However, the grass has proved to be prone to attack by leafhoppers and sod webworm which likes the tender shoots. If the latter pest is left unchecked, the lawn soon looks spotty and dried out. At the first sign of the yellow moths, he recommends applying an insecticide such as Malathion or Toxaphene, repeating in 10 days and again after a similar interval.

He makes the following comments: "Silt grass establishes well on heavy clay and clay-loam-peat-sand mixtures. It likes full sun; does not compete well with trees or thrive in shady locations. Must be cut regularly to a height of from ¾ inch to 1½ inches; the shorter preferred for a sculptured lawn. Builds up heavy thatch; does best with yearly dethatching and aeration. It is very drought-resistant but needs good amounts of water to achieve full green carpet effect. Responds well to fertilizer which should be applied every 2-3 months. It is very resistant to traffic. After establishment, can be walked upon even after heavy rains without damage. In fact, the more traffic it receives, the

fuller and more compact it seems to grow. It should be excellent for fairways. It grows rapidly and profusely and is hard to confine to a limited area—runners grow out, over and into everything. Even lawn trimmings, thrown out as refuse, take root. To establish and maintain a home lawn of this grass entails a lot of work. In non-saline situations, *Zoysia* lawns require much less care." Mr. Riese regards the two Spaanse Water lawns as good tests of silt grass under saline conditions. (45).

Trial in Venezuela

In April of this year, I obtained from Charles Mahannah a quantity of silt grass (35 lbs after washing off all of the soil) and sent it to Dr. Humberto Belloso, in Maracaibo, Venezuela, for trial, in cooperation with the Facultad Agronomía, Universidad del Zulia, in areas around Lake Maracaibo unfavorable for the growth of the better-known grasses. In a preliminary test, runners (in poor condition on arrival) were set ¾ inch to 1¾ inches deep in furrows 6 inches apart in a mixture of 50% sand, 50% goat manure, having a pH of 6.85 and electrical conductivity of 80 milimhos. These runners have produced excellent, lush, solid sod. In contrast, cuttings similarly placed by Ing. Efrén Mendoza Ravelo in typical urban Maracaibo soil with a pH of 7.2 and electrical conductivity of 160 milimhos have made sparse growth, not completely covering the soil, despite the lapse of nearly 5 months. Another planting is being made at a beach site (35).

Conclusion

I believe that silt grass should be tried in many wet coastal locations and that it should receive serious attention in Florida, not only for fairways, but as a potential lawn grass for seaside homes on the mainland and on the Keys.

Persons and Literature Cited

1. Adamson, R. S. and T. M. Salter. 1950. Flora of the Cape Peninsula. Juta & Co., Ltd., Cape Town and Johannesburg.
2. Backer, C. A. and R. C. Bakhuizen van den Brink, Jr. 1968. Flora of Java. Vol. 3. Wolters-Noordhoff N.V., Groningen, Netherlands.
3. Bailey, F. M. 1902. The Queensland Flora. Pt. IV. Queensland Gov't, Brisbane.
4. Baker, J. G. 1877. Flora of Mauritius and the Seychelles: A description of the Flowering Plants and Ferns of those Islands. L. Reeve & Co., London.
5. Barker, H. D. and W. S. Dardeau. 1930. La Flore d'Haiti. Service Technique du Departement de l'Agriculture, Port-au-Prince.
6. Baumgardner, T. M., T. Miesse Baumgardner Associates, Landscape Architects, Sea Island, Ga. Sept. 7 and 17, 1973. Personal communication.
7. Britton, N. L. Flora of Bermuda. 1918. Charles Scribner's Sons, New York.
8. ———— and C. F. Millspaugh. 1920. The Bahama Flora. Pub'd by authors, New York.
9. ———— and P. Wilson. 1923. Botany of Porto Rico and the Virgin Islands. Vol. 5, Pt. 1. Sci. Surv. P.R. and V.I., New York Academy of Sciences, New York.
10. Burcham, L. T. 1948. Observations on the Grass Flora of Certain Pacific Islands. Contrib. from U. S. Nat'l Herb. Vol. 30, Pt. 2. Smithsonian Inst., Washington, D. C.
11. Burkill, I. H. 1935. Dictionary of the Economic Plants of the Malay Peninsula. Vol. 2. Crown Agents for the Colonies, London.
12. Burt, Dr. E. O., Ornamental Horticulturist (Turf), Agricultural Research Center, Ft. Lauderdale, Fla. Aug. 31, 1973. Personal communication.
13. Christophersen, E. 1935. Flowering Plants of Samoa. Bul. 128. Bernice P. Bishop Museum, Honolulu.
14. Dalziel, J. M. 1948. Useful Plants of West Tropical Africa (Appendix to the Flora of W. T. A.). Crown Agents for the Colonies, London.
15. Ewart, A. J. and J. R. Tovey. 1909. The Weeds, Poison Plants and Naturalized Aliens of Victoria. Min. of Agric., Melbourne.
16. Gooding, E. G. B., A. R. Loveless and G. R. Proctor. 1965. Flora of Barbados. Overseas Res. Pub. #7. Her Majesty's Stat'y Off., London.
17. Grisebach, A. H. R. 1864. Flora of the British West Indian Islands. Lovell Reeve & Co., London.
18. Heyne, K. 1950. De Nuttige Planten van Indonesie. Vol. I. N. V. Uitgeverij W. van Hoeve 'S-Gravenhage/ Bandung.
19. Hitchcock, A. S. 1927. The Grasses of Ecuador, Peru and Bolivia. Contrib. U. S. Nat'l Herb. Vol. 24, Pt. 8. Smithsonian Inst., Washington, D. C.
20. ————. 1935. Manual of the Grasses of the United States. Misc. Pub. 200. U. S. Dept. Agric., Washington, D. C.
21. ————, and A. Chase. 1917. Grasses of the West Indies. Contrib. from the U. S. Nat'l Herb. Vol. 18, Pt. 7. Smithsonian Inst., Washington, D. C.
22. Latham, J. M., Chief Field Agronomist, Sewerage Commission of the City of Milwaukee. Sept. 5, 1973. Personal communication.
23. LeCointe, P. 1947. Arvores e Plantas Uteis. 2nd ed. Serie 5, Vol. 251, Brasiliana, Biblioteca Pedagogica Brasileira, Companhia Editora Nacional, Sao Paulo.
24. Leon, Hno. 1946. Flora de Cuba. Vol. I. Contrib. Ocas. #8, Museo de Hist. Nat. del Colegio de la Salle. Cultural, S.A., Havana.
25. Long, R. W. and O. Lakela. 1971. A Flora of Tropical Florida. Univ. of Miami Press, Coral Gables.
26. Macbride, J. F. 1936. Flora of Peru. Vol. XIII, Pt. I. Bot. Ser. Pub. 351. Field Mus. of Nat. Hist., Chicago.
27. Mahannah, Charles, Golf Course Architect, King's Bay Yacht and Country Club, Miami. 1971-3. Personal communications.
28. Maiden, J. H. 1889. Useful Native Plants of Australia (including Tasmania). Tech. Mus. of New South Wales, Sydney.
29. Malcolm, C. V. 1962. Plants for Salty Water. 2. J. Agric. West. Aust. 3 (10): 793-4.
30. ————. 1969. Saltland Pastures. J. Agric. West. Aust. 10 (3): 4th Ser. 119-122.
31. ————. 1969. Use of Halophytes for Forage. Production on Saline Wastelands. J. Aust. Inst. of Agric. Sci. 35 (1): 38-49.
32. ———— and I. A. F. Laing. 1969. **Paspalum vaginatum**—for salty seepages and lawns. J. Agric. West. Aust. 10 (11) 4th Ser.: 474-5.
33. ———— and S. T. Smith. 1971. Growing Plants with Salty Water. J. Agric. West. Aust. 12 (2) 4th Ser.: 41-4.
34. Manfred, L. 1947. 7000 Recetas Botanicas, a Base de 1300 Plantas Medicinales Americanas. Editoral Kier, Buenos Aires.
35. Mendoza Ravelo, E., Ingeniero, Facultad de Agronomia, Universidad del Zulia, Maracaibo, Venez. Oct. 3, 1973. Personal communication.
36. Merrill, E. D. 1922. An Enumeration of Philippine Flowering Plants. Vol. I. Bur. of Sci., Dept. of Agric. and Nat. Res., Manila.
37. Millspaugh, C. F. 1902. Flora of the Island of St. Croix. Pub. 68, Bot. Ser. Vol. I, #7. Field Colombian Mus., Chicago.
38. Morton, J. F. 1970-3. Field Notes (Venezuela, Florida, Georgia, Curacao).
39. Moscoso, R. M. 1943. Catalogus Florae Domingensis. Pt. I. Universidad de Santo Domingo, Ciudad Trujillo, D. R.
40. Muñoz Pizarro, C. 1966. Sinopsis de la Flora Chilena.

2nd ed. Ediciones de la Universidad de Chile, Santiago.
41. Perez-Arbelaez, E. 1956. Plantas Utiles de Colombia. 3rd ed. Libreria Colombiana—Camacho Roldan (Cia. Ltda), Bogotá.
42. Pittier, H. 1926. Manual de las Plantas Usuales de Venezuela. Pub'd by author, Caracas.
43. Pulle, A. 1948. Flora of Suriname. Vol. I, Pt. 1. Koninklijke Vereeniging Indisch Inst., Amsterdam.
44. Radford, A. E., H. E. Ahles and C. R. Bell. 1968. Manual of the Vascular Flora of the Carolinas. Univ. of North Carolina Press, Chapel Hill.
45. Riese, H. J., Managing Director, Boca Patrick Estate, Curacao, Netherlands Antilles. 1969-73. Personal communications.
46. Sauer, J. C. 1967. Plants and Man on the Seychelles Coast. Univ. of Wisconsin Press, Madison.
47. Schmeisser, Hans, Golf Course Architect, Gulfstream Golf Club, Delray Beach. Aug. 30, 1973. Personal communication.
48. Schmeisser, Otto, Superintendent, Indian Creek Golf Course. Aug. 38 and Oct. 9, 1973. Personal communications.
49. Schnee, L. 1960. Plantas Comunes de Venezuela. Alcance #3. Rev. de la Facultad de Agron., Univ. Central de Venez., Maracay.
50. Shiflet, T. N. 1963. Major Ecological Factors Controlling Plant Communities in Louisiana Marshes. J. Range Management 16: 231-5.
51. Small, J. K. 1933. Manual of the Southeastern Flora. Pub'd by the author, New York. (Reprinted by Univ. North Carolina Press, 1953).
52. Stahel, G. 1942. De Nuttige Planten van Suriname. Bul. 57. Departement Landbouwproefstation, Paramaribo.
53. Standley, P. C. 1937. Flora of Costa Rica. Pt. I. Pub. 391. Bot. Ser. Vol. 18, Field Mus. Nat. Hist., Chicago.
54. ————. 1928. Flora of the Panama Canal Zone. Contrib. U. S. Nat'l Herb. Vol. 27. Smithsonian Inst., Washington, D. C.
55. Stone, B. C. 1970. The Flora of Guam. Micronesica Vol. 6. University of Guam.
56. Swallen, J. R. 1936. The Grasses of British Honduras and the Peten, Guatemala. Pp. 141-189 & 4 pls., in Botany of the Maya Area. Misc. Papers. Pub. 461. Carnegie Inst., Washington, D. C.
57. Walker, A. R. and R. Sillans. 1961. Les Plantes Utiles de Gabon. (Encyc. Biologique LVI) Editions Paul LeChevalier, Paris.
58. White, R. Southern Turf Nurseries, Eustis, Fla. Sept. 6, 1973. Personal communication.
59. Woodson, R. E., R. W. Schery, et al. 1965. Flora of Panama, Pt. II. Fasc. I. Ann. of Mo. Bot. Gard. Vol. XXX, No. 2, 1943-4. Reprinted by Stechert-Hafner, New York.

DEEP ROOT INJECTION FEEDING, THEORY AND PRACTICE IN TREE AND SHRUB MAINTENANCE

H. C. BARDSLEY

Horticultural Consultant
F.E.C. Fertilizer Company
Homestead
and

C. P. JOHNSON, PRES.

Charlie P. Johnson Spray Co., Inc.
Miami

Abstract. **A discussion of the agronomic theory of placing plant nutrients in the root zone of ornamental trees and plants by high pressure hydraulic injection. Definite beneficial effects of deep root injection feeding by high pressure injection of plant nutrients have been observed in tree and ornamental plant installation and maintenance. The response outperformed conventional surface applications of plant nutrients. Speculation is made on the value of the addition of nematicides as well as systemic fungicides and insecticides to the plant nutrient injection. Deep root injection feeding is an effective method of tree and plant maintenance that does not violate the ecology.**

Introduction

Fertilizer placement in relation to a plants root system is often as important in plant response as the analyses and units of plant nutrients applied. There are varying filtering and tyingup capacities in different soils that alter the analyses and amounts of plant nutrients applied to the surface of soils and those available at the soil depth of the root system.

In recognition of the response of plant nutrients in fertilizer placement on ornamental shrubs and trees it has long been the established practice in many areas of the United States to provide more effective feeding by physically placing the nutrients in the plants root zone area of the soil profile. Techniques of "punching" holes with a crowbar or drilling holes in the soil with a special drill have been used to provide access to the root zone area and then conventional fertilizers or compressed nutrient tablets were placed in the holes in the soil around the shrub or tree. Recently hydraulic injection techniques have been employed using soluble or liquid plants nutrients. Hydraulic injection was first tried by Charlie P. Johnson in 1953 in the Miami area.

Early hydraulic injection treatments with liquid or soluble nutrients provided only short term responses and did not justify the economic costs for shrub and tree maintenance.

Most Florida soils offer a challenge to improved fertilizing techniques because of their very low natural fertility and often antagonistic effects on plant nutrients. Fertilizer placement on cul-