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SOIL CHARACTERISTICS OF FOUR *JUNCUS ROEMERIANUS* POPULATIONS IN MISSISSIPPI

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ABSTRACT The physical and chemical characteristics of soil from four widely separated *Juncus roemerianus* populations in Mississippi tidal marshes are determined. The *J. roemerianus* populations studied are located in Grand Bayou, Salt Flats, Weeks Bayou, and Belle Fontaine marshes. Organic matter, pH, CEC, N, P, K, Ca, S, Mg, and Zn analyses are based on composite soil samples. The percentage of sand, silt, and clay of the marsh soils is determined along with soil water content from the four locations. Statistical analysis indicates which marshes are different for each soil characteristic tested. No appreciable amounts of organic matter are present in the soils from Grand Bayou and the Salt Flats, however, the soils of Weeks Bayou and Belle Fontaine marsh are highly organic. Magnesium is significantly different among all locations. Concentrations of P are greatest in the marsh soils from Grand Bayou and lowest in the Salt Flats. Greater values are recorded for organic matter, CEC, N, K, Ca, S, Mg, and Zn in the Weeks Bayou and Belle Fontaine marsh soils than are recorded for the soils at Grand Bayou and Salt Flats. The results of the soil analyses show that tidal marsh soils vary considerably in physical and chemical characteristics among locations, and *J. roemerianus* is able to grow well in a variety of soil types.

INTRODUCTION

Tidal marshes in Mississippi form a thin border between the uplands and the Mississippi Sound. The marshes in Mississippi have been described by Eleuterius (1972) and Eleuterius and McDaniel (1978). These marshlands are dominated by the black needlerush *Juncus roemerianus* Scheele.

Tidal marsh soils along the Gulf Coast appear to be very diverse. Chabreck (1972) reported on the diversity of the vegetation, water, and soil characteristics of Louisiana marshlands. DeLaune et al. (1981) and Brupbacher et al. (1973) also reported on the chemical properties of marsh soils in Louisiana. The tidal marsh soils of the Florida Gulf Coast have been studied extensively by Coultas (1978a, 1978b) and Coultas and Gross (1975, 1977).

The relationships between the soils and the plant communities of Louisiana marshes have been studied by Palmisano and Chabreck (1972). They related chemical variables of the marsh soils with the distributions of major plant species in Louisiana. DeLaune et al. (1979) evaluated the relationship between soil properties and the biomass of *Spartina alterniflora*.

The objective of the present research is to compare soil characteristics from four populations of *J. roemerianus* located at widely separated locations along the Mississippi Coast and to determine the similarities and differences in the soils occupied by *J. roemerianus*.

MATERIALS AND METHODS

Composite soil samples were collected from four populations of *J. roemerianus*. Locations of the Grand Bayou, Salt Flats, Weeks Bayou and Belle Fontaine populations of *J. roemerianus* are shown on Figure 1. The soil samples were taken from the upper 5 to 15 cm of substrate and placed in plastic bags. Samples were frozen until the individual tests were performed. Soil water content, which is expressed as the ratio of the mass of water present in the sample to the mass of the dry sample and presented as a percent (Black 1965a), was obtained by oven drying the soil samples in seamless 180 ml cans at 105°C until dry. The marsh soils were analyzed by using standard methods (Black 1965b). Determinations were made of pH, cation-exchange capacity (CEC), organic matter, total nitrogen (N), acid-extractable phosphorus (P), potassium (K), calcium (Ca), sulfur (S), magnesium (Mg), and zinc (Zn). Individual chemical properties were compared among the four populations by analysis of variance (ANOVA) to determine statistical differences among the populations. The chemical properties which showed a significant difference were then subjected to Duncan's multiple range test, which indicated the population or populations that were statistically different, based on soil properties, from the other populations. The percentage of sand, silt, and clay contained in the soil was analyzed by granular metric methods, in which the sand values were obtained by sieving and the silt and clay values were obtained by hydrometer. These latter analyses were conducted by the Geology Section of the Gulf Coast Research Laboratory.

RESULTS

Soil physical characteristics obtained from the four locations dominated by *J. roemerianus* are shown in Table 1. Based on the percentage of soil water from the different locations, it can be shown that the retention of water by the soils from Weeks Bayou and Belle Fontaine is greater than that by the soils from the Salt Flats and Grand Bayou marshes. No measurable amounts of organic matter are found in the soil samples taken from Grand Bayou and the

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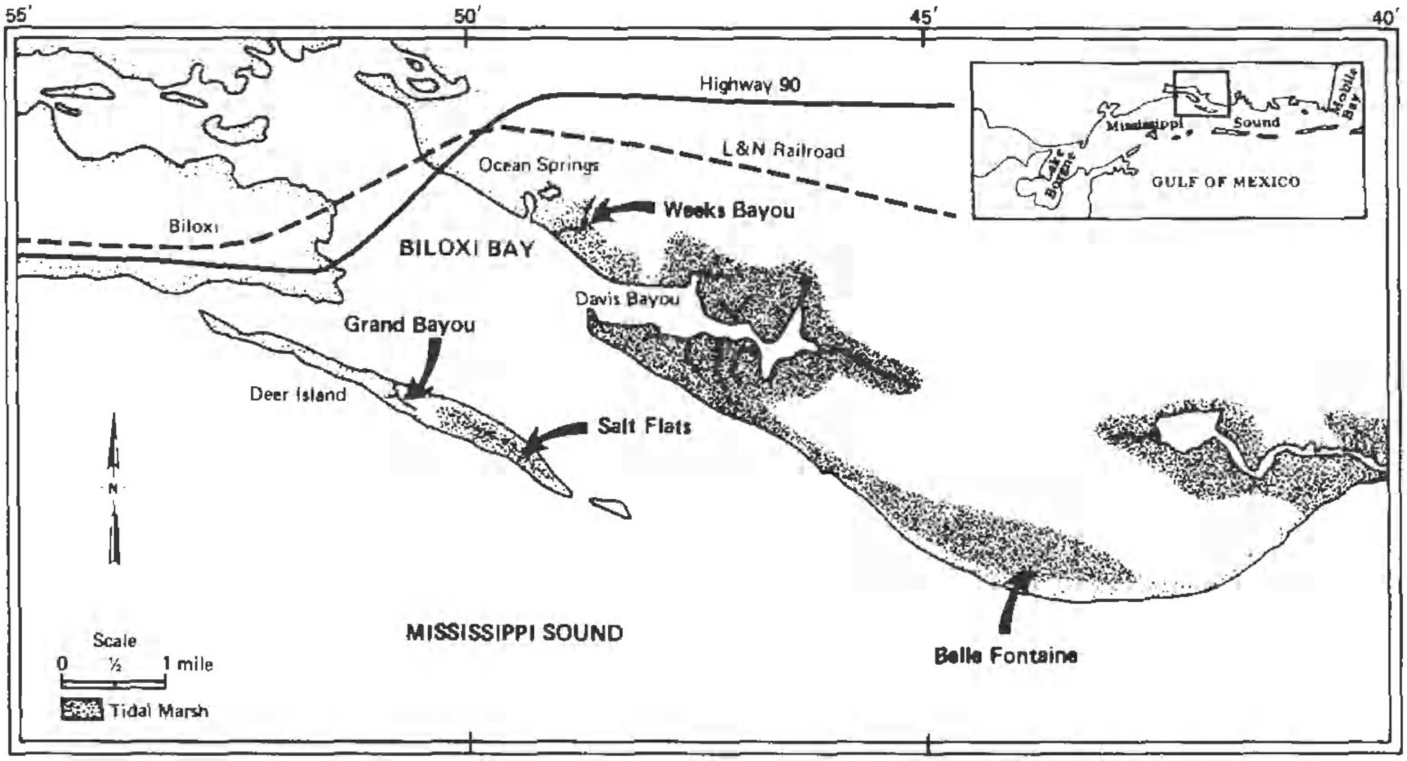

Figure 1. Locations of the four *Juncus roemerianus* populations studied are indicated by the arrows and names of the sites.

Salt Flats, but the organic matter in both the Weeks Bayou ($\bar{x}$ = 21.2%) and Belle Fontaine ($\bar{x}$ = 24.1%) soils is an important feature. The percent sand values show the Salt Flats soil has the greatest sand content and differs from all other locations. The Grand Bayou marsh soil, which is also high in sand content, also differs from the other locations. However, the relatively low sand values from Weeks Bayou and Belle Fontaine marshes do not show a difference. The silt and clay values, which are greater in the Weeks Bayou and Belle Fontaine marshes, do not differ. However, a difference occurs between these marshes and both the Salt Flats and Grand Bayou marshes, which are not different.

TABLE 1

Soil physical characteristics from four *Juncus roemerianus* locations. Mean values for percent soil water from two replicates. Mean values for the percent organic matter, sand, silt, and clay from six replicates. The organic matter values are the mean percentages for the total soil weight retained in the sieve series. Values in horizontal rows followed by the same capital letter are not significantly different (α = 0.05) according to Duncan's multiple range test.

Soil Physical Characteristics	Grand Bayou Marsh	Salt Flats Marsh	Weeks Bayou Marsh	Belle Fontaine Marsh	$F_{(3,20)}$
Organic Matter (%)	0.0 A	0.0 A	21.2 B	24.1 B	6.59†
Sand (%)	71.1 A	82.8 B	3.3 C	4.0 C	557.55†
Silt (%)	18.1 A	13.1 A	41.3 B	42.1 B	7.59†
Clay (%)	10.8 A	4.1 A	34.2 B	29.8 B	31.93†
Soil Water (%)	29.2	19.4	143.9	123.3	

†Significant at the 0.05 level.

The salinity of the soil water fluctuates frequently at these locations depending on the season, temperature, tidal pattern, and amount of precipitation (Eleuterius 1974). Soil water salinities are frequently observed as high as 300 ppt on the Salt Flats, but salinity values for soil water at the other three locations rarely exceeds 20 ppt.

The results of the Duncan's multiple range test on S, Ca, K, P, and pH do not show a difference between the Weeks Bayou and Belle Fontaine marshes; however, all the other combinations of marsh locations are different for these soil analyses (Table 2). The Grand Bayou and Salt Flats marshes are not different from each other and Weeks Bayou is not different from Belle Fontaine for Zn. Magnesium is different for all four locations. Organic matter, CEC, and N are not different for the Salt Flats and Grand Bayou marshes, however, all other combinations of marsh locations are different.

Although the values obtained from the soil chemical analyses vary greatly among the four locations, the Weeks Bayou and the Belle Fontaine marsh soils have greater concentrations of N, K, Ca, S, Mg, and Zn, and greater amounts of CEC and organic matter than are found in the marsh soils at Grand Bayou and the Salt Flats. The soils are more acidic in the marshes at Weeks Bayou and Belle Fontaine than those in the other two locations. However, the P concentration is greater in the soils from Grand Bayou than the other three locations. The Salt Flats soils have the lowest concentrations of P, and those at Weeks Bayou and Belle Fontaine are approximately the same.

TABLE 2

Soil characteristics from four locations dominated by *Juncus roemerianus*. Values are the mean and standard deviation of three replicates. Values in horizontal rows followed by the same capital letter are not significantly different ($\alpha = 0.05$) according to Duncan's multiple range test. Range values are in parenthesis.

Soil Analyses	Locations				$F_{(3,8)}$
	Grand Bayou Marsh	Salt Flats Marsh	Weeks Bayou Marsh	Belle Fontaine Marsh	
pH	7.5±0.05 A (7.5–7.6)	6.8±0.17 B (6.6–6.9)	6.1±0.15 C (5.9–6.2)	6.3±0.10 C (6.2–6.4)	75.78†
Cation-Exchange Capacity (meq/100g)	5.45±0.15 A	2.91±0.10 A	28.91±2.60 B	25.46±1.21 C	259.56†
Organic Matter (%)	0.58±0.13 A	0.00±0.00 A	18.88±0.36 B	17.12±1.03 C	1025.60†
Total Nitrogen (ppm)	433.0±43.5 A	211.0±10.0 A	5107.0±298.1 B	7277.3±392.8 C	600.75†
Phosphorus (ppm)	44.0±3.4 A	4.0±0.0 B	26.3±5.1 C	26.0±1.7 C	77.87†
Potassium (ppm)	278.0±41.1 A	145.0±7.5 B	529.0±51.3 C	482.0±30.8 C	72.19†
Calcium (ppm)	202.0±0.0 A	78.7±18.4 B	1355.3±70.7 C	1266.0±69.6 C	541.53†
Sulfur (ppm)	146.0±19.0 A	61.7±4.0 B	300.0±0.0 C	300.0±0.0 C	443.27†
Magnesium (ppm)	412.7±10.5 A	241.0±1.7 B	2327.3±67.6 C	2098.7±95.2 D	1045.08†
Zinc (ppm)	0.63±0.05 A	0.43±0.25 A	2.67±0.58 B	2.30±0.79 B	14.96†

†Significant at the 0.05 level.

DISCUSSION

In comparison to the marshlands located elsewhere along the northern Gulf of Mexico, no extensive, detailed studies have been conducted on the tidal marsh soils in Mississippi. However, the marsh soils along the Gulf Coast are shown to be very diverse in physical and chemical properties by comparing the works of Chabreck (1972), Patrick et al. (1977), DeLaune et al. (1979), DeLaune et al. (1981) in Louisiana, and Coultas (1978a) in Florida. Although differences in the salt marsh vegetation have also been reported in the marshes of the northern Gulf of Mexico by Palmisano and Chabreck (1972) in Louisiana and Eleuterius (1972) in Mississippi, no clear relation to soil type was noted.

Water retention by soils depends largely on their physical structure. Tidal marsh soils that have a high sand content are more likely to lose soil water rapidly when exposed by low tides, than soils with a high organic content. Therefore, the structure, density, and other physical aspects of tidal marsh soils are important to all water relationships of plant species that grow in them. The soil characteristics reported in this study show that the marsh soils vary among the four locations; however, some similarities in the soils are also indicated. Soil pH values ranged from 5.9 to 7.6 for the four locations. These values are typical for tidal marsh soils and the range of our values corresponds to those reported by Chabreck (1972) for soil pH in saline marsh where *J. roemerianus* occurs in Louisiana.

Boyd (1970) showed that the concentrations of nitrogen and sulfur were directly related to the amount of organic matter found in aquatic soils. This relationship is also evident in our data. The greater concentrations of N and S found in the marsh soils of Weeks Bayou and Belle Fontaine correspond to greater organic matter content in the soils at the same locations. Boyd (1970) and Coultas and Gross (1975) stated that cation-exchange capacity of tidal marsh soils increases correspondingly with an increase in organic matter content. The higher the cation-exchange capacity of a soil, the greater the ability of the soil for trapping cations. Thus, cation-exchange capacity of tidal marsh soils varies directly with organic content (Boyd 1970, Coultas 1978a). This direct relationship between cation-exchange capacity and organic matter is clearly shown in our data. The Grand Bayou and the Salt Flats soils are low in organic matter and these soils also have correspondingly lower cation-exchange capacity values than the higher organic soils of Weeks Bayou and Belle Fontaine. Farwell et al. (1979) also showed that sulfur compounds volatilized from soils at different moisture contents. Such volatilization obviously occurs in tidal marsh soils in Mississippi. Smith and DeLaune (1983) reported gaseous loss of nitrogen from Louisiana marshes. George and Antoine (1982) showed that temperatures, soil pH, and substrate concentrations affect denitrification.

Brupbacher et al. (1973) reported large variations in the amounts of the elements magnesium, calcium, and potassium in the soils from the marshlands of Louisiana. The results from our data also show a wide range for these elements which varied as follows: Mg, 241 to 2327 ppm; Ca, 78 to 1355 ppm; K, 145 to 529 ppm. These fluctuations depend in part on daily and seasonal tidal levels, rainfall, and temperature.

Variations of soil phosphorus in marshlands have been shown by Brupbacher et al. (1973). Palmisano (1970) and Palmisano and Chabreck (1972) have reported that lower phosphorus concentrations are associated with greater amounts of organic matter in the soil. Phosphorus is found in variable concentrations at the different marshes in the present study. The greatest P concentrations are found in the soils at Grand Bayou, which are low in organic matter content. However, Weeks Bayou and Belle Fontaine marshes, which are high in organic matter content, have lower P concentrations than the Grand Bayou marsh. The reason for the low P concentrations found in the soils at the Salt Flats, which are also very low in organic matter, is not clear.

Zinc concentrations in marsh soils at the mouths of several rivers along the Atlantic Coast, which are dominated by *S. alterniflora*, have been reported by Dunstan and Windom (1975). They reported zinc concentrations in the sediments that ranged from 14.9 to 69.6 ppm. However, the Zn concentrations reported in the present study are considerably lower (0.43 to 2.67 ppm). The reason for the considerable differences in the amount of Zn between locations on the Mississippi Gulf Coast and those on the Atlantic Coast is not known. DeLaune et al. (1981) have shown that plant nutrients and heavy metals accumulate in salt marshes through sedimentation and accretion. However, Patrick et al. (1977) showed that redox affected nutrient availability in coastal wetlands. They found that although certain plant nutrients are present in marsh soils, their availability to certain marsh plants may be restricted. Waisel (1972) has pointed out that the nutrient uptake mechanism varies among halophytes. Eleuterius and Caldwell (1981) have shown that the absence of K, S, P, and Mg caused severe growth retardation and was essential to the growth of *J. roemerianus*. The absence of Ca, N, and Fe had a less severe effect on growth, indicating that *J. roemerianus* is physiologically peculiar. *J. roemerianus* may have a completely different physiological mechanism for uptake and utilization of nitrogen in comparison to what is presently known for most halophytes and terrestrial plants. It was not our purpose to compare nutrient concentration with plant growth or production. However, Valiela and Teal (1974) indicated that nitrogen availability was the most limiting and regulating factor in plant production on tidal wetlands. Patrick and DeLaune (1976) showed the pattern of nitrogen and phosphorus utilization by *S. alterniflora*. Their work indicated that nitrogen was the most important nutrient limiting the growth of the grass *S. alterniflora*. A similar relationship for the rush *J. roemerianus* has not been established. Furthermore, Smith and DeLaune (1984) and Mendelssohn (1982) indicated that the rhizosphere and "deposits" found on the roots of *S. alterniflora* were related to the nutrition of the plant. They indicated that the area immediately around the root had different nutrient concentrations than the surrounding soil. "Deposits" on the roots were also found to have different concentrations of nutrients than the surrounding soil. No such "deposits" are found on the roots of *J. roemerianus*.

Our study shows that *J. roemerianus* is able to grow in a variety of marsh habitats that have different chemical and physical soil properties. Extensive monotypic and almost pure stands of *J. roemerianus* are formed over a wide range of soil types. In other local marsh areas *J. roemerianus* grows intermixed with other plant species. The reason for exclusion of other species from some populations is not known. The soils in the areas studied range from sand and clay, which are relatively low in organic matter and nutrients (Salt Flats and Grand Bayou), to the mud and peat soils which are high in organic matter and have correspondingly high concentrations of nutrients (Weeks Bayou and Belle Fontaine). The wide distribution of *J. roemerianus* in the tidal marshes of Mississippi and throughout the distributional range of the species is apparently related in part to the ability of the species to occupy a variety of soil types and nutrient regimes.

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