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Effect of Soil Factors on Vegetation Values of Salt Marsh Plant Communities: Multiple Regression Model

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ABSTRACT: The objective of the current study was to characterize and apply multiple regression model relating to vegetation values of the plant species over salt marshes. For each salt marsh community, vegetation and soil variables were investigated in the western coast and the southern coast in South Korea. Osmotic potential of soil and Cl^- content of soil as independent variable had positive and negative influences on vegetation values. Multiple regression model showed that vegetation values of 14 coastal plant communities were determined by pH of soil, osmotic potential of soil and sand content. The multiple regression equation may be applied to the explanation of distribution and abundance of plant communities with exiting ordination plots.

Key words: Coastal plant community, Multiple regression model, Osmotic potential, Sand content, Vegetation value

INTRODUCTION

Salt marshes embody boundary characteristics of terrestrial and marine communities. They are plastic coastal features, shaped by the interaction of water, sediments and vegetation. For stability, they require protection from high-energy waves and therefore usually develop in sheltered salt marshes. In some parts of the world they show extremely diverse vegetation, while in other regions they are dominated by a few plant species, usually grasses (Ihm et al. 2001a, Isacch et al. 2006). A better understanding of the environmental factors that determine plant community structure is a major goal of plant ecologists studying coastal wetlands. Sharp spatial boundaries of plant species on coastal wetland have been observed along environmental gradients (Armstrong et al. 1985). In controlling the distribution and abundance of wetland plants within and across coastal wetlands types, factors related to hydrology, salinity and soil texture are believed to play a major role (Ustin et al. 1982, Brewer and Grace 1990, Glenn et al. 1991, Ihm and Lee 1998).

In South Korea, the coastal communities are among the most poorly understood vegetation units, although research has been conducted on the physiognomic, floristic, and ecophysiological characteristics of halophytic species (Kim 1971, 1975, Kim et al. 1982, Kim and Song 1983, Oh and Ihm 1983, Ihm and Lee 1998, Jung and Kim 1998, Min and Kim 1999a, 1999b, 2000). The objective of the current study was to characterize and apply multiple regression model relating to the vegetation values of the plant communities over salt marshes.

MATERIAL AND METHODS

Two coastal areas in South Korea were investigated: 1) the western coast at Kimje, Iksan, Kochang, Yongkwang, Hampyung, Muan, Shinan, and Yongam; 2) the southern coast at Haenam, Changhung, Bosung, Sunchon, and Masan. Coastal vegetation in these regions was monitored from September 1997 to August 2001. Salt marshes were described according to their hydrology, salinity, soil texture, etc. (Ihm and Lee, 1998, Ihm et al. 2001a, b).

For each community, we measured data of twelve soil variables on vegetation value (VV) (= cover (%) in quadrat × plant height (cm), %·cm or cm^3), which indicates occupying or dominant volume and competitive ability as the dependent variable for multiple regression analysis of vegetation (Lee and Park 2005). In order to examine the soil environment near the roots, samples were taken at a depth of 10 cm from the surface. Air-dried samples of soils were used for physico-chemical analysis. Water potential and osmotic potential of soils were determined by the method of Ihm (1989). Soil texture was determined by the Köhn's apparatus method. Organic matter content of soil was determined by ashing the samples at 550℃ for 4hr. Electrical conductivity and pH of soil were measured by S-C-T meter (YSI Model 33) and Orion Ion-analyser (Model 407A), using a water to fresh soil ratio of about 5:1(w/w).

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Total Kjeldahl nitrogen content of soil was determined by micro-Kjeldahl method (Allen et al. 1986). Cl^- content of soil was measured by argentometric method (Kalthoff and Stenger 1947) and Na^+ content of soil was measured by flame photometer (Coleman 51).

These soil variables were entered into a backward stepwise multiple regression with vegetation values as the dependent variable (SAS 2000). We constructed linear models to evaluate significant correlations between these soil variables and vegetation values. The significant variables at the 0.1000 level were selected in the model.

RESULTS AND DISCUSSION

Vegetation value ranged from 900 to 9,000 in 14 plant communities of salt marshes. pH of soil ranged from 5.6 to 7.2. Water potential of soil ranged from −5.13 to −0.95 MPa. Soil moisture content ranged from 15.3 to 29.0%. Osmotic potential of soil ranged from −3.83 to −0.75 MPa. Electrical conductivity of soil ranged from 0.63 to 1.92 mS/cm. Cl^- content of soil ranged from 1.8 to 22.2 mg/g. Na^+ content of soil ranged from 3.9 to 21.3 mg/g. Total Kjeldahl nitrogen of soil ranged from 0.15 to 0.65 mg/g. Organic matter content of soil ranged from 2.6 to 4.9%. Sand content of soil ranged from 8 to 82%. Silt content of soil ranged from 11 to 62%. Clay content of soil ranged from 8 to 33%.

In simple regression models analyzed to account for the vegetation value variability, r in models using osmotic potential of soil and Cl^- content of soil as independent variable are 0.541 and 0.618 (both P<0.05). Osmotic potential and Cl^- content had positive and negative influences on vegetation values (Table 1, Fig. 1 and 2). The relationships between vegetation value and pH, water potential, moisture content, electrical conductivity, Na^+ content, total Kjeldahl nitrogen content, organic matter content and contents of sand, silt and clay were not statistically significant (P > 0.05, Table 1).

In multiple regression models analyzed to account for the vegetation value variability, r in model using soil variables as indepen-

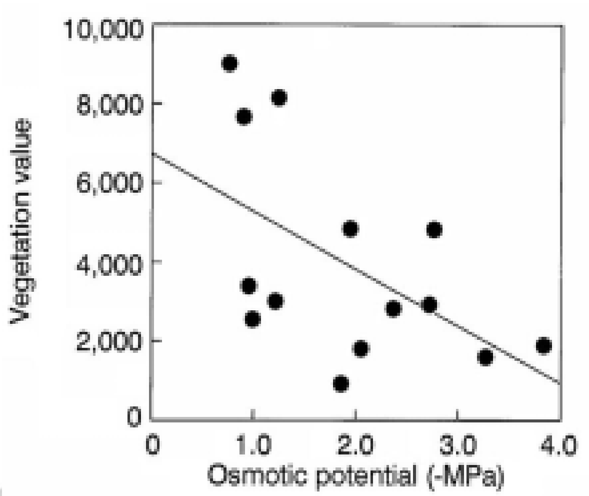

Fig. 1. Relationship between vegetation value and osmotic potential of soil for 14 plant communities of salt marshes. The regression line is shown in Table 1.

Table 1. Simple regression analyses relating to vegetation values as dependent variables in 14 plant communities of salt marshes

Independent variable	*Regression coefficient*	*Intercept*	*r*	N	*P*
pH	1,543.417	-6,280.338	0.237	14	NS
Water potential (-MPa)	-970.810	6,362.831	0.473	14	NS
Moisture content (%)	-66.929	5,453.795	0.114	14	NS
Osmotic potential (-MPa)	-1,444.888	6,714.503	0.541	14	<0.05
Electrical conductivity (mS/cm)	-2,835.548	6,750.530	0.396	14	NS
Cl^- content (mg/g)	-245.955	6,212.613	0.618	14	<0.05
Na^+ content (mg/g)	-170.773	5,704.345	0.395	14	NS
Total Kjeldahl nitrogen (mg/g)	5,087.890	2,140.353	0.295	14	NS
Organic matter (%)	526.397	1,980.336	0.148	14	NS
Sand (%)	13.065	3,298.171	0.122	14	NS
Silt (%)	-18.231	4,521.373	0.118	14	NS
Clay (%)	-35.366	4,611.237	0.114	14	NS

NS, P>0.05.

dent variable is 0.831. The variability in vegetation value could be explained by three variables of soil pH, osmotic potential of soil and sand content of soil (Table 2 and *Eq.* 1): $P > F$ of soil pH, osmotic potential and sand content were 0.024, 0.0011 and 0.0107, respectively. The 3 soil variables were significant at the 0.05 level. Soil pH and osmotic potential had positive influences on vegetation values, but sand content of soil had negative influences.

The 14 coastal plant communities were plotted in the space defined by the vegetation value observed and the vegetation value predicted by the multiple regression model (Fig. 3). *Zoysia sinica*, *Suaeda japonica* and *Limonium tetragonum* communities were located in salt marshes with low osmotic potential and sand content of soil and high pH of soil. *Phacelurus latifolius*, *Scirpus fluviatilis* and *Phragmites communis* communities were located in salt marshes with high osmotic potential and sand content of soil and low pH of soil. With exiting ordination plots such as Canonical Correspondence Analysis (CCA), Detrended Correspondence Analysis (DCA), Principal Component Analysis (PCA) etc., the equation of Multiple Regression Analysis (MRA) can be used for explaining plant abundance and distribution (Gauch 1982, Digby and Kempton 1987, Jongman et al. 1995).

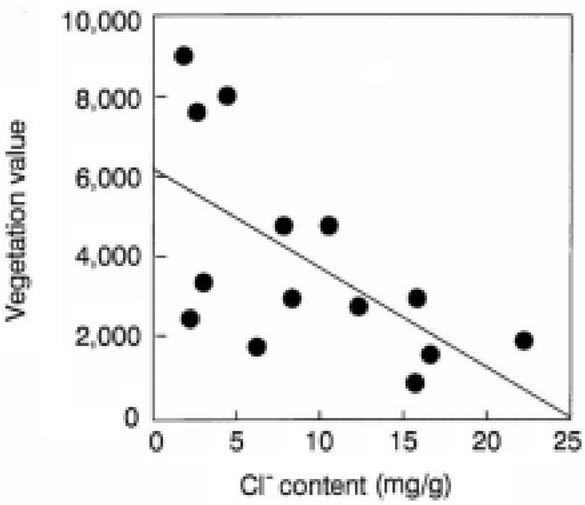

Fig. 2. Relationship between vegetation value and Cl^- content of soil for 14 plant communities of salt marshes. The regression line is shown in Table 1.

Table 2. Type II SS, *F* value and $P > F$ of soil pH, osmotic potential and sand content in backward stepwise multiple regression

Variable	Type II SS	*F* value	$P > F$
Intercept	1,979,403	0.75	0.407
pH	18,842,045	7.12	0.024
Osmotic potential	53,601,236	20.25	0.0011
Sand content	25,913,658	9.79	0.0107

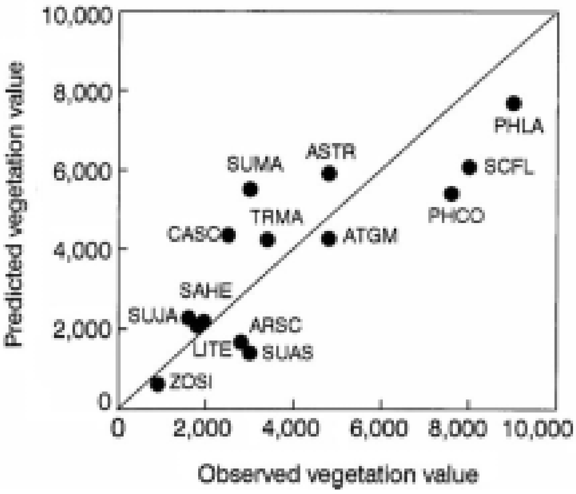

Fig. 3. Relationship between the vegetation value observed and the vegetation value predicted by the multiple regression model. The diagonal line represents that predicted values are equal to observed ones. SAHE: *Salicornia herbacea*, SUJA: *Suaeda japonica*, SUAS: *Suaeda asparagoides*, ATGM: *Atriplex gmelini*, ARSC: *Artemisia scoparia*, LITE: *Limonium tetragonum*, ASTR: *Aster tripolium*, JOSI: *Zoysia sinica*, SUMA: *Suaeda maritima*, SCFL: *Scirpus fluviatilis*, PHCO: *Phragmites communis*, CASC: *Carex scabrifolia*, TRMA: *Triglochin maritimum*, PHLA: *Phacelurus latifolius.*

$$\text{Vegetation value} = -6659.826 + 3248.345\ (\text{pH}) - 3345.134\ (\text{Osmotic potential}) - 93.426\ (\text{Sand content})\ (r = 0.831,\ P < 0.01) \quad (1)$$

Salt marsh vegetation is generally characterized by simplicity of structure and uniform species composition (Asri and Ghorbanli 1997). Each of our communities had one or sometimes two dominants with or without associated species. *Suaeda herbacea, S. japonica* and *S. maritima* are known as a pioneer species on reclaimed land and salt marsh with low soil osmotic potential (−5.0 MPa), low sand content of soil and high light intensity (Kim 1971, Chapman 1974, Beeftink 1977, Kim and Song 1983, Ihm and Lee 1998, Ihm et al. 2001a). Also, several salt marsh species were located in estuaries or in salt marshes supplied by fresh water springs. They were dominated by *Carex scabrifolia, Phragmites communis*, *Scirpus fluviatilis* and *Triglochin maritimum* communities. They were located mostly in salt marshes with high soil osmotic potential and sand content of soil (Oh and Ihm 1983, Kim and Song 1983, Ihm et al. 2001a, b).

Because vegetation values were consistent with typical distribution patterns of plant communities, we suggest that pH of soil, osmotic potential of soil and sand content play the primary role in determining plant distribution. Ihm and Lee (1998) reported that edaphic factors related to water potential of soil, salinity and soil texture also affected the distribution and abundance of wetland plants within and across coastal wetland types. Similar results were found in the same or other areas (Min and Kim 1999a, b, Kim and Ihm 1988, Ihm et al. 2001a).

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