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RESEARCH ARTICLE

STUDIES ON FACTORS INFLUENCING DISTRIBUTION OF *IPOMOEA PES CAPRAE* ALONG SUPRA LITTORAL ZONE, SANDY BEACHES OF PONDICHERRY, SOUTHEAST COAST OF INDIA

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ABSTRACT

Field observation on the distributions of a coastal plant *Ipomoea pes-caprae* along the sandy beach of Puducherry (northern part) revealed that *Ipomoea pescaprae* was growing profusely only along supra - littoral zone (Plant zone) of the sandy coastal region. An attempt to understand the factors that influenced such restricted distribution along the supra-littoral zone revealed that fine sand with medium grains with low pH and EC along with moisture and organic carbon collectively influenced the distribution. Further, 't' test confirmed the observation that pH, Electrical conductivity of the soil, Organic carbon, soil texture, moisture and nitrogen content of the soil are influencing the distribution of *Ipomoea pes caprae* significant at 99.9% level along the supra-littoral zone in the sandy beaches.

INTRODUCTION

Coastal sandy beaches are the natural structures and their flora are the natural resources which together protect the coastal environment by absorbing energy from wind, tide and wave action (Corre Jean-Jacqes, 1991). These species are playing a vital role in protecting the coast from erosion and flooding (Desai, 2000). Beaches feature a constant exchange of sand, organic matter and nutrients, inputs that influence the distribution and growth of beach organisms. Beaches do not have a stable substratum; usually consist of loose deposits of sand, crushed shells, rocks, gravel and pebbles as a result there are no large plants to provide food for beach organisms. The literature survey revealed that studies identifying the major environmental factors associated with coastal vegetation, are very wanted except for the reports of Li, (1993) Wu *et al*. (1994) Wang *et al*. (1994), Hu and Wang, (1997); Toth *et al*. (1995) and Liu *et al*. (2003). Many of these studies are just descriptive documentation of species distributed and their classification (Ukpong, 1994; Feoli *et al*. (2002) but not relating to factors that influence their distribution and growth along sandy beaches. Presently, an attempt is made to examine the factors influencing the distribution and growth of *Ipomoea pes-carpae* along the sandy beaches of Pondicherry coast with particular reference to Northern part of Pondicherry beach with a specific objective to examine the factors influencing the distribution of *Ipomoea pes caprae* along the supra littoral zone in the Pondicherry coast.

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MATERIALS AND METHODS

Ipomoea pes-caprae (family Convolvulaceae -commonly referred to as railroad vine/morning glory), is a tropical vine that routinely colonizes sandy beaches. These are runners and are succulent and have a milky colored sap. It is one of the most widely distributed beach plants throughout tropical and subtropical areas around the world successfully occupying the supra littoral regions of sandy beaches forming large mats that assist in stabilizing sands. (Fig.1 a and b). Fig. 1 (a and b) Google earth image showing distribution of *Ipomoea.pes caprae* along supra littoral zone of Pondicherry sandy coast

Fig. 1. Google sat map showing distribution of *Ipomoea pes caprae* along supra littoral zone of Pondicherry northern coast

Soil samples were collected from 6 sites where *Ipomoea pes-caprae* is growing (supra littoral zone) and Non – Plant zone (High tide zone) where *Ipomoea pes capae* is not available. The sampling was done every month for the period of 6 months covering two seasons viz. Post monsoon and summer (December-May). Soil samples were collected with wooden tools to pit was dug out samples using wooden tool. From each pit samples was collected from a depth of 0-30 cm. approximately 1 Kg of soil from each site and put in plastic bags, and the bags tied to prevent moisture loss. This was done both in supra littoral zone (where Ipomoea pescaprae are growing) and high tide zone-where there is no plant.

Soil moisture in each sample was determined immediately after bring into a laboratory by weight loss after heating at 105°C for 24h and expressed as a percent dry weight. Samples were then air dried at room temperature (27±1°C) for 24-48h, then all the samples were packed in the polythene bags for laboratory investigations. By using this air dried samples following physical and chemical parameters were analysed following the methods: pH meter with combined electrode ECmS/cm^2) Electrical conductivity instrument. Conductometry (Jackson 1973); Moisture Hot air-oven Gravimetric**;** Organic carbon, Hot-air-oven, muffle furnace; Loss of Weight on Ignition (LOI) method. (Salehi *et al.,* 2011); Macro and micro nutrients Bruker S4-Pioneer instrument; Total nitrogen Macro Kjeldahl method **(**Bremner and Mulvaney 1982); Grade analysis Sieve analysis (or) Gradation Test (Simon J. Blott and Kenneth Pye, 2012). Student “t test” was used to find out the significance of each factor between two different soil i.e. Supra littoral zone (plant zone) and High tide zone (non-plant zone).

RESULTS

The soil pH is greater in non-plant zone (High tide zone) when compared to plant zone (Supra littoral zone), pH ranges from (7.48-8.47) in Plant Zone (Supra littoral zone) and (8.22-9.52) in a non-plant zone (High tide zone). The Electrical conductivity (EC) is also greater in non-plant zone (High tide zone), EC ranges from (0.841-1.294mS) in non-plant zone (High tide zone) and (0.016-0.145 mS) in a plant zone (Supra littoral zone). In contrast, organic carbon and total nitrogen amounts are greater in a plant zone (Supra littoral zone) than non-plant zone (High tide zone). Organic carbon ranges from (0.51.0.106%) in plant zone (Supra littoral zone) and (0.02-0.8%) in a non plant zone (High tide zone) and total nitrogen values are (0.0084-0.127%) in plant zone (Supra littoral zone) and (0.0015-0.0058%) in a non-plant zone (High tide zone). Moisture is also greater in a non-plant zone (High tide zone) than plant zone (Supra littoral zone) (Table 2).

Soil texture analyses revealed that Gravel, Very Coarse, Coarse are greater in non-plant zone (High tide zone); Medium and fine particles are higher in a plant zone (Supra littoral zone). Very fine particles are only present in a plant zone (Supra littoral zone) and silt is absent in both zones except in the month of December. The ‘t’ test confirmed the observation that pH, Electrical conductivity of the soil, Organic carbon ,soil texture, moisture and nitrogen content of the soil are influencing the growth of *Ipomoea pes caprae* significant at 99.9% level.

DISCUSSION

Sandy beaches are an important ecosystem that links the ecology of sand dunes, the surf zone, intertidal zones, and nearby rocky reefs. Sandy Coastal beaches and dunes flora have immense effect in coastal and dune stabilization and restoration. Phyto-resources of coastal sandy zones are having great socio-economical values which remains unexplored to most of the people, thus results in destruction and removal of dune floras continuously. Such sensitive and useful ecosystems need immediate restoration, conservation actions and sustainable use of the phyto-resources. (Tamal chakraborty *et al*., 2012). But none the less many plant species are able to colonize supralittoral sands, despite initially poor nutrient conditions, lack of moisture, and sometimes very high temperature. Such colonization may, on sheltered beaches, begin at or just above the strandline aided by accumulations of wrack and tidal litter, which reduce the sand temperature and increase its moisture content (McLachlan and Brown, 2006). In this pursuit, it is clear from the literature that most previous studies on soil-vegetation interrelationship have tended to concentrate on soil characteristics under single vegetation units while others have compared characteristics of soils under natural vegetation.

In the present study, field observation on the distributions of a coastal plant *Ipomoea pes-caprae* along the sandy beach of Puducherry (northern part) revealed that *Ipomoea pes caprae* was growing profusely only along supra - littoral zone (Plant zone) of the sandy coastal region, whereas in the adjacent tidal zone (i.e.) high tide zone (Non-plant zone) towards the sea side is devoid of *Ipomoea pes-caprae* (Fig. 2). Therefore, it is attempted to find out what factors limit the distribution and growth of Ipomoea pes-caprae along the supra-littoral zone (Plant zone) alone The physico - Chemical parameters of the soil of both supra littoral zone (Plant zone) and high tide zone (Non - plant Zone) has revealed the pH, EC along with micronutrients alike N and high ratio of C:N significantly varied between these zone. Lower pH and EC values with nitrogen content might have facilitated the distribution of *Ipomoea pes-caprae* along Supra Littoral zone. Conversely, the higher pH and EC with poor values of nitrogen in the high tide zone, might not be influencing the growth of Ipomoea pes-caprae along High tide zone. Cannone *et al*. (2008) have reported that vegetation was related to the chemistry of the surface - soil layer, including nitrate, organic carbon, C/N ration and water content, and also soil texture.

Further, Lie *et al*. (2008) clearly stated that plant - soil relationship of saline coastal plain of north China revealed that salinity, pH, moisture and available nitrogen were the major soil factors responsible for variations in the pattern of vegetation. These reports are close conformity with justify the present findings. Poor nutrients status, low cation exchanges capacity (CEC) and soil organic matters along with reduced microbial activity are the major constraints soil quality. Kalleswari *et al*. (2005) also indicated that, the amount and quality of organic carbon are crucial factors influencing soil productivity. Such observations are made in the present study where major constraints in the high tide zone (Non - plant zone) in the poor nutrients and high pH and Electrical conductivity.

Table 1. Physico-chemical characteristics of soil

	Soil Parameter	December	January	February	March	April	May	P-value
pH	Plant zone (Supra littoral)	7.993±0.38	8.133±0.26	7.947±0.32	7.884±0.26	8.142± 0.44	8.412± 0.66	*
	Non-plant zone (High tide zone)	9.350±0.13	8.573±0.27	8.452±0.24	9.672±0.88	9.214±1.07	9.294±0.86	*
EC(mS/cm2)	Plant zone (Supra littoral)	0.057±0.04	0.103±0.03	0.050±0.02	0.094±0.03	0.054±0.06	0.725±0.08	***
	Non-plant zone (High tide zone)	1.137±0.07	0.949±0.10	1.196±0.05	1.082±0.07	1.048±0.02	0.988±0.06	***
OC (%)	Plant zone (Supra littoral)	0.078±0.03	0.070±0.02	0.072±0.02	0.082±0.03	0.078±0.02	0.072±0.06	*
	Non-plant zone (High tide zone)	0.037±0.005	0.033±0.02	0.032±0.02	0.044±0.06	0.038±0.03	0.032±0.07	*
Moisture (%)	Plant zone (Supra littoral)	1.458±0.56	0.702±0.44	0.614±0.20	0.682±0.32	0.721±0.43	0.894±0.22	***
	Non-plant zone (High tide zone)	5.676±1.28	6.671±1.47	4.613±0.88	5.268±1.33	6.224±0.87	5.826±0.85	***
Total N (%)	Plant zone (Supra littoral)	0.009±0.001	0.009±0.001	0.011±0.002	0.004±0.001	0.008±0.002	0.009±0.002	***
	Non-plant zone (High tide zone)	0.004±0.001	0.003±0.001	0.004±0.001	0.002±0.001	0.004±0.002	0.004±0.001	***
C:N	Plant zone (Supra littoral)	8.67:1	7.78:1	6.55:1	7.246:1	8.442:1	8.024:1	**
	Non-plant zone (High tide zone)	9.25:1	11:1	8:1	8.85:1	10.5:1	9.4:1	*

***** =P<0.05(95%); ** =P<0.01(99%); ***=P<0.001(99.9%)

Table 2. Soil texture

	Soil Type	December	January	February	March	April	May	P-value
Gravel	Plant zone (Supra littoral)	0.23±0.16	0.07±0.17	nil	0.04±0.002	0.02±0.006	nil	*
	Non-plant zone (High tide zone)	0.39±0.003	0.053±0.007	0.035±0.009	0.046±0.005	0.054±0.004	0.040±0.003	*
Very coarse	Plant zone (Supra littoral)	1.18±0.28	1.29±0.65	1.47±0.28	1.42±0.12	1.24±0.21	1.14±0.17	*
	Non-plant zone (High tide zone)	3.04±2.77	1.10±1.34	0.91±0.35	1.02±0.80	0.942±0.98	1.324±1.12	*
Coarse	Plant zone (Supra littoral)	138.34±8.73	131.71±7.73	143.91±5.26	164.2±11.2	148.2±8.43	150.6±6.98	*
	Non-plant zone (High tide zone)	160.84±6.41	145.41±8.63	150.78±4.48	160.51±8.88	145.4±6.88	145.2±8.66	*
Medium	Plant zone (Supra littoral)	56.83±7.58	63.06±8.98	51.10±5.26	43.44±3.99	42.2±6.55	46.6±4.92	*
	Non-plant zone (High tide zone)	33.47±7.58	43.96±7.24	45.36±4.96	40.24±8.65	32.62±5.88	34.84±7.53	*
Fine	Plant zone (Supra littoral)	0.80±0.58	1.01±0.64	0.48±0.25	0.424±0.46	0.782±0.68	1.824±0.87	*
	Non-plant zone (High tide zone)	0.12±0.06	0.152±0.13	0.17±0.16	0.142±0.66	0.114±.008	0.124±0.102	*
Very fine	Plant zone (Supra littoral)	0.07±0.04	0.03±0.02	0.02±0.01	0.02±0.11	0.03±0.02	0.03±0.01	***
	Non-plant zone (High tide zone)	Nil	Nil	nil	Nil	0.02±	nil	***
Silt	Plant zone (Supra littoral)	0.035±0.04	Nil	Nil	0.040±0.01	Nil	Nil	*
	Non-plant zone (High tide zone)	Nil	Nil	Nil	Nil	Nil	Nil	*

P<0.05(95%); ** =P<0.01(99%); ***=P<0.001(99.9%)

Table 3. NUTRIENTS (Ca, Mg, S, Na and Cl)

	Nutrients	December	January	February	March	April	May	P-value
Ca	Plant zone (Supra littoral)	4.37±1.45	4.31±0.36	4.32±0.43	4.421±0.83	4.382±	4.444±0.88	*
	Non-plant zone (High tide zone)	3.79±0.37	3.57±0.75	2.85±0.49	3.42±0.44	3.72±	3.34±0.85	*
Mg	Plant zone (Supra littoral)	0.48±0.15	0.58±0.09	0.58±0.09	0.543±0.16	0.58±	0.52±0.21	*
	Non-plant zone (High tide zone)	0.32±0.006	0.39±0.11	0.32±0.009	0.28±0.66	0.34±	0.38±0.13	*
S	Plant zone (Supra littoral)	0.009±0.02	0.037±0.09	Nil	0.004±0.001	0.028±	Nil	*
	Non-plant zone (High tide zone)	0.033±0.03	0.036±0.02	0.11±0.03	0.02±0.008	0.007±	Nil	*
Na	Plant zone (Supra littoral)	1.12±0.039	1.31±0.12	1.33±0.05	1.32±0.08	1.241±	1.142±0.67	*
	Non-plant zone (High tide zone)	1.26±0.03	1.34±0.09	1.67±0.09	1.32±0.45	1.266±	1.204±0.89	*
Cl	Plant zone (Supra littoral)	Nil	Nil	0.035±0.05	Nil	0.033±	Nil	*
	Non-plant zone (High tide zone)	0.35±0.03	0.24±0.05	1.07±0.22	0.46±0.12	0.29±0.08	0.62±0.26	**

=P<0.05(95%); ** =P<0.01(99%); ***=P<0.001(99.9%)

Table 4. Nutrients (Fe, Mn, Cu, P and K)

	Nutrients	December	January	February	March	April	May	P-value
Fe	Plant zone (Supra littoral)	5.25±1.99	5.27±0.97	4.05±0.56	4.62±0.86	5.34±1.34	5.14±0.87	*
	Non-plant zone (High tide zone)	3.11±0.68	2.91±0.94	1.9±0.47	3.42±0.73	2.82±1.06	2.02±0.84	-
Mn	Plant zone (Supra littoral)	0.1±0.04	0.11±0.03	0.07±0.01	0.08±0.03	0.10±0.08	0.08±0.02	**
	Non-plant zone (High tide zone)	0.04±0.02	0.05±0.016	0.019±0.02	0.05±0.008	0.03±0.007	0.04±0.02	**
Cu	Plant zone (Supra littoral)	0.003±0.008	0.016±0.001	0.012±0.019	0.002±0.001	Nil	0.004±0.0008	-
	Non-plant zone (High tide zone)	0.007±0.01	0.013±0.07	0.018±0.001	-	0.006±0.001	0.002±0.001	-
P	Plant zone (Supra littoral)	0.07±0.03	0.21±0.06	0.07±0.01	0.17±0.08	0.210±0.08	0.120±0.056	*
	Non-plant zone (High tide zone)	Nil	0.11±0.019	0.06±0.05	-	0.08±0.02	0.06±0.02	-
K	Plant zone (Supra littoral)	3.38±1.18	3.05±0.33	3.38±0.18	3.32±1.02	3.02±0.89	3.14±0.87	*
	Non-plant zone (High tide zone)	4.5±0.37	3.74±0.42	4.44±0.30	4.72±1.08	3.84±1.03	4.02±1.02	*

***** =P<0.05(95%); ** =P<0.01(99%); ***=P<0.001(99.9%)

Regarding the lower values of pH and Electrical conductivity in the plant Zone (Supra littoral zone) indicate that Ipomoea pes-caprae is adapted to growing in sandy soil with lower pH and Electrical conductivity (Table 1).

As stated by Black (1993) the pH of soil significantly affects plant growth, primarily due to the change in availability of both essential elements such as Phosporus; On the otherhand, the higher vaue sof pH and EC along hilgh tide zone due to periodic wet by the tidal water, is not condusive for the growth of *Ipomoea pes capra*. Zare *et al*. (2011) identified soil texture, salinity, effective soil depth, available nitrogen, potassium, organic matter, lime and soil moisture as major soil factors responsible for variations in the pattern of vegetation; Medinski (2007) identified clay + silt, EC and pH to influence the distribution and life to form abundance (Iwara *et al*., 2011). Understanding the relationship between certain soil properties and specific flora species would act as a guide to farmers, horticulturists and land use planners alike to recognize the likely soil conditions that are suitable for a particular purpose (Veeranjaneyulu and Dhanaraju 1990).

The soil texture also indicated that growth of *Ipomoea pes-caprae* could be facilitated by medium and fine sands present in the supra littoral zone or high up in the hightide zone. It is clear from the soil texture analysis (Table 2) that soil texture of both plant zones (Supra littoral zone - high up in the coats), and the Non- plant zone (high tide zone) showed significant relationship with distribution. Further, reports of Singaravel *et al*. (2005) revealed that coastal line is dominated by sandy light textured soils. Soils with finer particles and with higher organic matter can generally provide a greater reserve of these elements whereas, coarse textured soils such as, sand have fewer reserves and tend to get depleted rather quickly. (Vijayakumar *et al*., 2011). It was also reported previously that clay + silt, EC and pH to influence by McLachlan and Brown, (2006) that many plant species are able to colonize supra - littoral sands, despite initially poor nutrient conditions, lack of moisture, and sometimes very high temperatures. Such colonization may, on sheltered beaches, begin at or just above the strandline aided by accumulations of wrack and tidal litter, which reduce the sand temperature and increase its moisture content. Moreover, these are also in conformity with the reports of Bell and Dell, (2008) that growth is controlled by physico-chemical properties like: soil texture, organic carbon and calcium carbonate, cation exchanges capacity, pH and electrical conductivity of soil. On examining the high level of moisture and Electrical conductivity in the non plant zone it is understood that in the plant zone (Supra littoral zone), the possibility for moisturisation of the soil is very least except the rainfall; whereas in the high tide zone (Non - plant zone), there is a periodic wetting of soil by the tidal water resulting in high level of moisture in the zone when compared to supra littoral zone (plant zone). It is evident to the reports of Naidoo and Raiman, (1982) and Hemajoshi and Ghose, (2003) that the soil salinity to be related with extent of tidal inundation and seepage in the mangrove soils of Sipingo and Mgeni, South Africa. Similarly, Electrical conductivity value also is higher because of moisturisation by the tidal water.

Thus, the present short term study on the relationship of physico - chemical parameters with the distribution of *Ipomoea pes-caprae* emphasises that due to due to global warming and melting of ice, world sandy beaches are experiencing sea-level rise couples with sea erosion. These fragile habitats are slowly becoming vulnerable in terms of species diversity linked with habitat transformation. Under such circumstances, these findings would provide hands on tips for growing *Ipomoea Pes-Caprae* along the supra littoral zone as a bio sand stabilizer and as aesthetic values while we plan for integrated coastal management programmes. As rightly pointed out by Tamal Chakraborty *et al*. (2012) such sensitive and useful ecosystems need immediate restoration and conservation actions. Current management of beaches has been mainly centred on physical aspects such as sand supply, stability and erosion interventions and growing sandy plants. As we face new challenges such as climate change we believe that the sustainable management of sandy beaches, nearshore reefs and sand dunes requires an integrated approach that also encompasses the ecological values of these crucial ecosystems.

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