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Weed Spectrum of *Pokkali* Lands : The Salt Marsh Rice Ecosystem of Kerala

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The *Pokkali* lands, known after the *Pokkali* type of cultivation, are located in the coastal areas of Ernakulam and Alapuzzha districts of Kerala covering an area of 8,800 ha. They are low lying acid saline marshes found near the mouth of streams and rivers flowing to the Arabian Sea. Soils of *Pokkali* lands are deep, impervious, clayey in texture, rich in organic matter, very low in phosphorus, medium in nitrogen and high in potassium with pH ranging from 3.1 to 4.8, in spite of high conductivity. Most of these soils have EC value higher than 14 dSm^{-1}. In its natural state, this area is over grown with mangrove and other salt loving vegetation. However, over the years, people have developed a practice of raising one crop of rice during the first crop season from May-June to September-October, when the floodwater due to the heavy south-west monsoon dilutes and pushes out the saline water from the fields. The farmers have developed special agronomic practices to overcome the problems from salinity, which includes use of saline tolerant rice varieties as well as raising rice seedlings on the ridges/mounds and subsequent spreading into the main field. This cultivation method is known as *Pokkali* cultivation. After the rice, the land is utilized for fish and prawn

Table 1. Distribution and dominance of weeds in *Pokkali* lands

Weed species	Frequency (%)	Density (No. m^{-2})	Relative frequency (%)	Relative density (%)	Relative importance value (%)
Grasses					
Diplachne fusca Beauv.	85	17.17	13.38	9.07	11.23
Echinochloa crusgalli (L.) Beauv.	80	13.93	12.59	7.36	9.98
Panicum repens L.	10	3.50	1.57	1.84	1.71
Sedges					
Fimbristylis miliacea (L.) Vahl.	55	8.27	8.6	4.37	6.48
Eleocharis dulcis (N. Burman) Henschel	45	9.50	7.08	5.02	6.05
Cyperus difformis L.	25	6.20	3.93	3.27	3.60
Broad leaf weeds					
Eichhornia crassipes Solms	30	14.33	4.72	7.57	6.15
Lemna polyrrhiza L.	5	20.00	0.78	10.57	5.67
Pistia statiotes L.	3	12.60	4.7	6.65	5.67
Monochoria vaginalis (Burm. f) Presl. ex Kunth.	50	5.50	7.87	2.9	5.38
Alternanthera sessilis (L.) DC	45	6.50	7.08	3.43	5.25
Nymphaea nouchali Burm. f	35	6.28	5.51	3.31	4.41
Sphenoclea zeylanica Gaertn.	40	4.12	6.26	2.17	4.23
Ludwigia parviflora Roxb.	25	5.40	3.93	2.85	3.39
Sphaeranthus africanus L.	10	8.50	1.57	4.49	3.03
Ferns					
Salvinia molesta Mitchell	15	25.00	2.36	13.21	7.65
Azolla pinnata R. Br.	5	18.00	0.78	9.51	5.15
Ceratopteris thalictroides Brang.	45	4.40	7.08	2.32	4.70

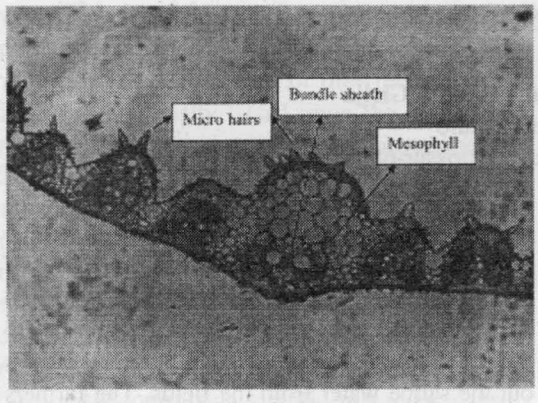

Fig. 1a. Cross section of leaf of *Diplachne fusca* showing 'Kranz anatomy' and micro hairs.

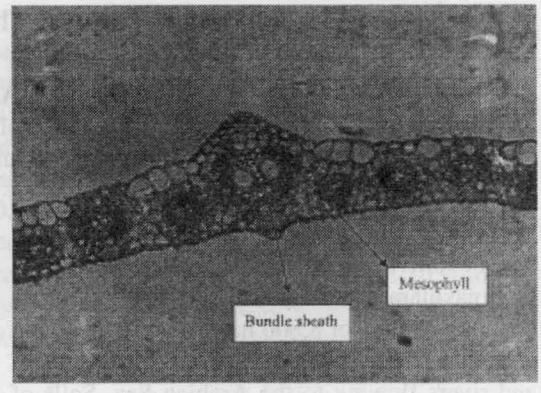

Fig. 1b. Cross section of leaf of *Echinochloa crusgalli* showing 'Kranz anatomy'.

culture, during the saline phase in summer months.

The weed flora of *Pokkali* rice fields is different from that of the ordinary rice fields under the fresh water ecosystem. However, studies on the weed flora and their adaptation to special ecological condition are meager though it is essential for developing appropriate weed management recommendations. Therefore, a survey was conducted, covering all the panchayats where *Pokkali* rice cultivation is practised, to identify the major weeds and to understand their distribution, importance and adaptations in the saline ecosystem.

A total of 20 sites were selected for the survey. Fields with very low weed intensities were avoided for the survey. In each field, species-wise counts of weeds were taken from three spots using a quadrat of 1 m x 1 m size and the mean was recorded.

Data Analysis

To understand the distribution and dynamics of the weeds, weed vegetation parameters such as frequency (F), density (D), relative frequency (RF), relative density (RD) and relative importance value (RIV) were worked out as suggested by Wentworth *et al.* (1984).

To study the adaptive mechanisms of weeds found to be specific to the saline soil condition, anatomical studies were performed on individual weed species. Cuttings of the flag leaf of the grass species *Diplachne fusca* and *Echinochloa crusgalli* were taken and preserved in FAA. Free hand sections were taken from these cuttings, stained with saffranine and mounted in DPX after washing in alcohol series. The sections were observed under microscope and photographs were taken.

A total of 18 weeds species were observed in the *Pokkali* rice fields, which included three grasses, three sedges, nine broad leaf weeds and three ferns (Table 1). When the weeds were ranked based on the RIV, the grass weed *D. fusca* emerged as the most dominant weed species of *Pokkali* lands, occurring in about 85% of the sites surveyed. The other important grass weed was *Echinochloa crusgalli* (RIV : 9.98) with a frequency of 80%. Among the sedges, *Fimbristylis miliacea* (frequency : 55%, RIV : 6.48) and *Eleocharis dulcis* (frequency : 45%, RIV : 6.05) were the dominant species. *Cyperus difformis* (RIV : 3.6) occurred in lesser proportions. Another species of *Cyperus,* namely, *C. javanicus* found in the paddy field bunds, was typically adapted to the saline soils of *Pokkali* lands. The broad leaf weed population was dominated by *Eichhornia crassipes, Monochoria vaginalis, Nymphaea nouchali* and *Pistia stratiotes,* which are usually seen in water-logged conditions. But the presence of two other broad leaf weeds *Sphenoclea zeylanica* and *Sphaeranthus africanus* is worth mentioning due

to their high adaptability to brackish water.

Among the three ferns observed, *Salvinia molesta* was the most important one with a RIV of 7.65. Two other ferns, namely, *Acanthus ilicifolius* and *Acrostichum aureum,* were found inhabiting the paddy field bunds and abandoned rice fields of *Pokkali* region. They are not observed in any other rice ecosystem of Kerala indicating their high preference of saline soils.

Mechanisms for Salt Tolerance

The anatomical characteristics of *D. fusca* and *E. crusgalli,* which were found specific to *Pokkali* rice fields, were also investigated.

The cross section of leaves of *D. fusca* and *E. crusgalli,* the most important grass weeds of *Pokkali* lands, revealed the presence of Kranz anatomy (Fig. 1a & 1b), which is typical of the C_4 plants. They have efficient photosynthesis and lower transpiration rate limiting salt uptake. The high photosynthetic efficiency helps these plants to grow bigger in size, which is regarded as an adaptation to thrive in the saline habitats as the ions taken up can be diluted by the growth or succulence. Atkinson *et al.* (1967) and Yeo and Flower (1986) suggested such dilution as a mechanism of salt tolerance in the mangrove species *Rhizophora mucronata* and *Spartina maritima. E. crusgalli* is a glycophyte (plants seen in saline as well as non-saline conditions), the plants of which are observed to be smaller in size in the fresh water ecosystems, whereas it grows to about more than 2 m height with large inflorescence and long awns in the saline habitats.

In addition to the efficient growth in *D. fusca,* the cross section of the leaf showed microhairs which function as salt glands which are reported to secrete salt on the leaf surface (Gorham, 1987). It is recommended as a crop for improving the physical, chemical and biological properties of salt affected soils, in addition to giving palatable fodder to farm animals.

The study revealed that the salt marsh ecosystem of the *Pokkali* lands had a special weed flora with anatomical and morphological modifications to maintain the salt balance in the plant.

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