Biology of Salt Tolerant Plants
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Chapter 11

PRODUCTIVITY OF AN ARTHROCNEMUM INDICUM DOMINATED COASTAL SALT MARSH AT KARACHI, PAKISTAN

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Belowground and aboveground (live and dead) biomass were measured in the seaward, Intermediate and landward zone of stands of *Arthrocnemum indicum* in Karachi, Pakistan at monthly intervals for one year. Net primary productivity (growth) and mortality was calculated from these data. Biomass production showed a seasonal pattern. Aboveground biomass increased substantially in July and persisted at the same level through out the year. Dead biomass showed a peaked in July while it remained unchanged during the rest of the study period. The belowground biomass of landward and intermediate zones increases significantly during late winter, spring and early summer and then declined in late summer. However, the belowground biomass in seaward zone remain unchanged. The estimate of net primary productivity computed from changes in plant biomass were: seaward zone 972 g m^{-2}, intermediate zone 1198 g m^{-2} and landward zone 1420 g m^{-2}.

INTRODUCTION

Edaphic characteristics of coastal salt marshes generally exhibit gradients from low to high salt marsh that correspond with elevation and the frequency of tidal inundation (Ellison et al., 1986; Bertness and Ellison, 1987; Pennings and Callaway, 1992). Edaphic factors that exhibit such gradients have repeatedly been shown to affect marsh plant success: productivity of some marsh plants is strongly influenced by flooding (Mahall and Park, 1976; Pennings and Callaway, 1992), nutrient limitation (Valiela et al., 1978), peat accumulation (Bertness, 1988), salinity (DeJong, 1978) and competition (Pennings and Callaway, 1992).

Primary production and species composition of salt marshes depend on tidal inundation, salinity, soil nutrient concentration, climate, marsh physiognomy, sedimentation processes, and sea level changes relative to the land (Bertness, 1988). Salt marshes ranked among the most productive ecosystems in the world, ranging from about 200-2000g C/m^2/year (Keenish, 1986). Gallagher (1978) has done a comprehensive review of above ground production of salt marshes and Good et al., (1982) of belowground production. Aboveground estimates of primary production of salt marshes range from approximately 300 to 400 gram dry weight m^{-2} $year^{-1}$ (Gallagher, 1978). Belowground production of structural material, such as roots and rhizomes are at least equal to or greater than the above ground production (Good et al., 1982).

Arthrocnemum indicum Willd. (Chenopodiaceae) is a perennial halophytic shrub, commonly found in tropical salt marshes which are frequently inundated with seawater. *A. indicum* is characterized by its bushy appearance and occurs in almost pure patches rarely with other species (Karim and Qadir, 1979). There is no data available on the aboveground or belowground productivity of Arabian sea coastal marshes.

The objective of this study is to follow the seasonal variation in aboveground and belowground productivity in different zones of an Arabian sea coast *A. indicum* salt marsh located at the Sands Pit beach, Karachi, Pakistan.

MATERIALS AND METHODS

Karachi city lies between the Latitude 24°51$^{/}$ North and Longitude 65° 55$^{/}$ East. The study area is located in Monora channel near Sandspit at Karachi, Pakistan. This salt marsh is regularly inundated with sea water and is dominated by an almost pure population of *Arthrocnemum indicum*.

Coastal salt marshes dominated by *A. indicum* can be divided into three zones i.e. Seaward, Intermediate and Landward. Every fourth week for one year nine plots were selected for harvesting in each of the three zones. Plants in three selected plots (0.25 m^2) in each zones were clipped close to the soil surface and separated into living and dead parts. Litter remaining on the marsh surface after clipping was collected separately. The soil was removed from the plot to a depth of maximum root penetration (approximately 50 cm). The belowground materials was separated by washing the soil thoroughly through sieve with water. In plot # 2 all of the living shoot material was removed but all of the dead plant material left in place. All of the plant samples were dried in an oven at 80 ^{o}C until a constant weight was achieved. After eight weeks the dead shoots were collected from plot # 2 and the living shoots, dead shoots and total below ground materials from plot # 3. The plant material was dried and weighed as reported above. Soil conductivity of the soil collected monthly was measured with a Radiometer CD - 83, conductivity meter.

RESULTS AND DISCUSSIONS

Soil conductivity - The soil conductivity showed a progressive increase from February and peaked in May and then substantially declined and remained low for rest of the year (Fig. 1). This sharp decline in conductivity can be correlated with the incidence of monsoon

Fig.1. Variation in soil conductivity during the growing season in all three zones i.e. Seaward (SZ), Intermediate (IZ) and Landward (LZ) of the*Arthrocnemum indicum* community.

rains. The year 1994 received four times above the average rainfall for the area. Rainfall started early in monsoon period and persisted until the very end of the monsoon, dumping in total about 840 mm of rain.

Aboveground biomass - Figures 2 and 3 display the monthly biomass of live and dead vegetation in three zones of the coastal *A. indicum* community. The plants collected from the three zones exhibited a similar live standing biomass pattern, with sharp increases in July that were maintained through December (Fig. 2). Minimum live biomass was recorded in winter and spring in all three zones. The biomass production in the seaward zone was significantly ($p = 0.001$) lower as compared to intermediate and

Fig. 2. Standing crop biomass of living plant material from all three zones i.e. Seaward (SZ), Intermediate (IZ) and Landward (LZ) of the *Arthrocnemum indicum* community.

Fig. 3. Standing crop biomass of dead plant material from all three zones i.e. Seaward (SZ), Intermediate (IZ) and Landward (LZ) of the *Arthrocnemum indicum* community.

landward zone. The biomass production was similar in intermediate and landward zones. The living biomass production correlates with soil conductivity data, which was high during winter and early spring, and a substantial decrease was noticed after June due to massive rainfall (Fig. 1). The dead biomass fractions shown in Fig 3 showed a tremendous increase during May in all of the zones. However, the increase in intermediate and landward zones were significantly higher than the seaward zone. The live/dead biomass fractions shown in Fig. 4 indicate that all three zones had a live/dead biomass peak which occurred in summer and fall. There was no difference among the zones. The standing crop of the living plants at a given time was a function of the earlier growth and mortality. Growth (Fig. 5) rate was very low during fall, winter and early spring. However,

Fig. 4. Live/dead biomass fraction for all three zones i.e. Seaward (SZ), Intermediate (IZ) and Landward (LZ) of the *Arthrocnemum indicum* community.

Fig. 5. Growth in stands of all three zones i.e. Seaward (SZ), Intermediate (IZ) and Landward (LZ) of the *Arthrocnemum indicum* community.

growth rate increased significantly during late spring and summer. This increase was much greater in the land ward zone. During fall it showed the negative growth.

Monsoon rains associated with soil conductivity primarily determines the productivity of *A. indicum* dominated salt marsh present at Manora creek near sands pit, Karachi, Pakistan. Standing crop above ground live biomass significantly increase after the monsoon rains in June 1994. Biomass of this tropical salt marsh peaked at 5 kg m^{-2}. The effect of differing hydroperiods are usually prominent in most published discussions of physical factors affecting marsh production (Jervis, 1964; Langlois, 1971; Steever et al., 1976; Odum et al., 1983). Soil salinities and temperature were very high before the rainfall period and this could result in the substantial reduction in above ground biomass. High temperature and salinity caused lower plant production in Indian River Lagoon, Florida (Rey et al., 1990) and in California (Zedler et al., 1980). The above ground production of *A. indicum* salt marsh ranges from 972 to 1420 g m^{-2} yr^{-1} which was in agreement with with vlues fo *Salicornia* marshes in California (300 - 1200 g m^{-2} yr^{-1}, Zedler, 1982), and *Batis maritima* and *Salicornia virginica* marshes in Georgia respectively, (1,149 g m^{-2} yr^{-1} and 600 g m^{-2} yr^{-1} , Antlfinger and Dunn, 1979) and from *Salicornia europaea* marshes in Massachussets (234 g m^{-2} yr^{-1}, Rubber and Murray, 1978). Dawes (1991) reported the aboveground estimates of primary production of salt marshes ranged from approximately 300 - 4000 g m^{-2} yr^{-1}. Clark and Jacoby (1994) reported that the above ground biomass of *Juncus Kraussi* in Australia ranged from 96 - 4400 g m^{-2} yr^{-1} and for *Sporobolus virginicus* it ranged from 148 - 852 g m^{-2} yr^{-1}.

In all the zones of *A. indicum* studied the live/dead biomass fraction peak occurred in early summer and was maintained through the rest of the year. Seasonal change in the pattern in live/dead biomass was also reported for *Spartina alterniflora* (Gallagher et al., 1980). Growth of *A. indicum* dropped to a minimum in all zones in August while mortality began to rise 3 months earlier. The net growth rate in *A. indicum* salt marsh ranged from 972 g m^{-2} yr^{-1} to 1420 g m^{-2} yr^{-1}.

Belowground biomass - The maximum recorded belowground standing crop at Intermediate and Landward zones was 1900 g m^{-2} (Fig. 6). In the seaward zone there was little variation in biomass throughout the year. Landward and Intermediate zones showed an almost five fold increase during late spring and summer and decline in August.

Fig. 6. Belowground biomass of living plant material from all three zones i.e. Seaward (SZ), Intermediate (IZ) and Landward (LZ) of the *Arthrocnemum indicum* community.

Data on belowground productivity estimates of halophytes are still fragmentary (Good et al., 1982). Belowground productivity estimates of *Spartina alterniflora* from Massachusetts (Valiela et al., 1976), New Jersey (Good, 1977; Good and Frasco, 1979; Smith et al., 1979), and Georgia (Gallagher and Plumely, 1979) were in reasonable close agreement with each other (2 - 3.5 kg m^{-2} yr^{-1}) and much higher than estimates (0.46 - 0.56 kg m^{-2} yr^{-1}) from North Carolina (Stroud, 1976; Smith and Odum, 1981). Estimate of other salt marsh species particularly from tropical salt marshes are limited but species such as *Sporobolus virginicus, Salicornia virginica,* and *Borrichia frutescens* had relatively modest belowground production (Good et al., 1982). Groenendijk and Vink - Lievaart (1987) reported the maximum biomass values found for *Spartina anglica, Elymus pycanthus, Halimione portulacoides* and *Triglochin maritima* were *12.58, 9.72, 17.74, and 16.12* kg m^{-2}, respectively. The *A. indicum* community in Pakistan in comparison produced a maximum biomass of 5 kg m^{-2} which is relatively low. This could be due to low rainfall and high aridity as compared to areas reported by Groenendijk and Vink - Lievaart (1987).

The occurrence of a seasonal peak in below ground biomass appears to vary some what among species. For *Spartina alterniflora*, peak below ground biomass occurs in late spring-summer with sites at lower latitudes being generally earlier (Stroud, 1976; Valiela et al., 1976; White et al., 1978; Good and Frasco, 1979; Hains, 1979; Smith et al., 1979). A small secondary biomass peak at the end of the growing season (October - November) has also been reported (Stroud, 1976; White et al., 1978; Hains, 1979; Smith et al., 1979). Peak belowground biomass of *Distichlis spicata* has been found to occur in August (Gallagher and Plumley, 1979; Good and Frasco, 1979), while a biomass peak in April and September were found for *Sporobolus virginicus* (Gallagher and Plumley, 1979).

Our data for a Karachi, Pakistan salt marsh dominated by *A. indicum* indicates little difference in all three zones except for belowground biomass production which did not change during the study period. Aboveground biomass production increased with an increase in unusually high and persistent rainfall. This could also be the reason for high productivity. We feel that to get an approximation of the net productivity rate and total biomass estimates of Karachi marshes would require long term studies (2-3 years) and large number of replicates.

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