Ecohydrological Influence on Growth and Clump Maintenance of *Potamogeton Crispus* L. in Punyamati River, Panauti

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Abstract

The main objective of the study was to assess growth and clump maintenance of *Potamogeton crispus* L. in two different beds of lotic habitat. Phenology and quantitative observation on P. *crispus* growing in Punyamati River were made in consideration with its hydroclimatic conditions. The stream flow rate of the Punyamati, which is a tributary of Rosi River, is less than $1m^3$/sec whereas that of the Rosi River is $3m^3$/sec. However, the sediment load is high owing to the land-use pattern in its catchment. The sediment load is 1.240 g/L^{-1} on an average, with the highest value of 6.842g/L^{-2} being in August, and has a significant effect on water quality and biomass and phenology of the aquatic macrophytes within.

The temperature of water varied from 12-22°C throughout the study period. The study period was from January to December, 1993. Flowering and turion formation occurred almost simultaneously from April to early July when water temperature was higher than 18°C and the photoperiod was longer than 12 hours. The total stem length (including above and underground stems) reached a maximum of 1,888m/m^{-2} in the river bed, with gravel and little sand deposits, and 4,293m/m^{-2} in the river bed, with silt and sand deposits, in March 1993. Though the plant produced numerous turions (8,100 turions /m^{-2}/$year^{-1}$), they were small (3-15mg dry wt./$turion^{-1}$) and found to be less important than underground stems for clump maintenance; while the stems were firmly rooted in bottom sediments in both of the river beds and protected by it from being swept away. Plants are covered by incoming sediments in rainy season which reinforced its hold on river bed, and new shoots developed from the underground stem again after the water flow receded. Most of the turions were washed downstream immediately after they were detached from the parent shoots. Turions are less important in plant propagation, but their role in new colony establishment in impounded areas of river accumulating silt is remarkable.

Introduction

Streams and rivers are open ecosystems that are heavily influenced by interaction with adjacent systems. Research has recognised the importance of characteristics of hydroclimate and materials and energy exchange between stream and surrounding terrestrial environments. These factors have profound effect on all the organisms living within the system.

Potamogeton crispus L. is an eurytopic submerged aquatic plant which flourishes in various aquatic habitats, e.g., in deep and shallow water, in sand or mud bottoms, in stony bottoms, and in stagnant pools or flowing streams. It has jointed slender, leafy branched stems bearing fibrous roots at lower nodes with creeping rootstock. All leaves are submerged, alternate, semi-amplexicaul, linear to linear oblong, and obtuse with crisped and finally serrated margins. Flowers are small, crowded in few spikes, sheathed by the stipules in the bud and the peduncle is curved tapering upwards. The perianth is of four segments, is velvet green, and concave with four stamens and four carpels. The fruit is small, with obliquely ovoid long-beaked druplets.

This study was carried out to clarify the mechanisms of the continuous growth and clump maintenance of P. *crispus* in a lotic habitat with different bed types and hydroclimates by phenological observations as well as by biomass measurements.

The Study Site and Methods

Study Site : Punyamati River in the central hills of Nepal was selected for the study. The river is 13km long from its source to the confluence with the Rosi River. It is 8.2m wide at the study site. The study site was located at 27° 34' N latitude and 85° 30' E longitude at an altitude of about 1,480m. Various sites of the river were visited in 1993 and two sites (station 1 and 2) were selected on the basis of observed differences in the growth pattern of P. *crispus*, and the type of river bed.

Station 1 was located just 2.5km upstream from the confluence of Punyamati River with Rosi River. In that area the river bed was composed of stone and pebbles with little silt deposits. The depth varied from 10-15cm in dry season and 100-150cm in rainy season. Station 2 was located just 0.5km downstream from station 1. The river bed was silty in that area. The depth was approximately 20cm in dry season and 100-160cm in rainy season. The silt accumulation was heavy due to the cross bridge barrier of large pipe laid over the river. Aquatic macrophytes consisted of *Hydrilla verlicellata* and *P. crispus.* But P. *crispus* was dominant over other macrophytes forming a single large mat covering the river bed.

Methods

Water samples were collected from the two sites throughout the study period using the standard methods of sampling and the physicochemical parameters of water like temperature, pH, conductivity, transparency, dissolved oxygen, biochemical oxygen demand, total hardness, and N-nitrite. The N-nitrate and orthophosphate were estimated by standard procedures (APHA, AWWA, and WPCF 1985).

Aquatic macrophytes of P. *crispus* was collected from a large mat growing on two sites at an interval of one month for one year from January to December, 1993, by throwing five quadrats of size 40cm x 40cm randomly. Thorough cleaning of the samples of each quadrat were carried out in the laboratory to remove the debris and attached algae. For biomass analysis, different isolated parts of P. *crispus* were kept in an oven for 24 hours at 80°C.

To evaluate the relationship between the physico-chemical parameters of water and biomass of *P. crispus,* correlation coefficients (r) were calculated and (r) values were tested at a five per cent level of significance.

Results and Discussion

General characteristics of the physico-chemical parameter and biomass of the plant *P. crispus* L. from stations 1 and 2 are presented in Figures 1 to 4 .

The stream flow rate of the Punyamati is less than $1m^3$/sec on the average whereas that of the Rosi River is $3m^3$/sec. In summer, however, it also exceeds more than $1m^3$/sec, resulting in a sediment load of 6.842g /L^{-1} in August (Fig. 1). This resulted in the covering of P. *crispus* mat by sediment and protected it from being washed away. The stream flow rate is closely related to the rainfall in its catchment, as the River Punyamati originates only from the Mahabharat Range where there are no snow peaks.

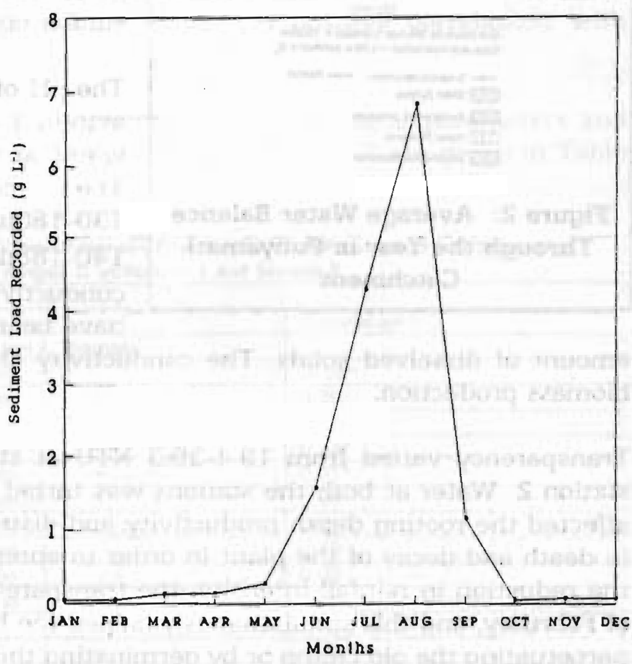

Figure 1: Mean Monthly Sediment Loads Recorded in gL^{-1}

The average water balance throughout the year in the Punyamati is presented in Figure 2. It shows the surplus water availability on the ground during four months of the year (i.e. from June to September). So, water surplus discharge in river is possible only within these months. The discharge increases the flow rate and simultaneously increases the sediment load, producing a remarkable effect on *P. crispus* productivity. The overall biomass in gm/m^2 was found to be decreasing, particularly for these four months of rainy season in both types of river bed. This could have been a result of the high flow rate and lower transparency rate of water for light penetration, indicating that the biomass decreases significantly in the above ground portion compared to that in the underground portion.

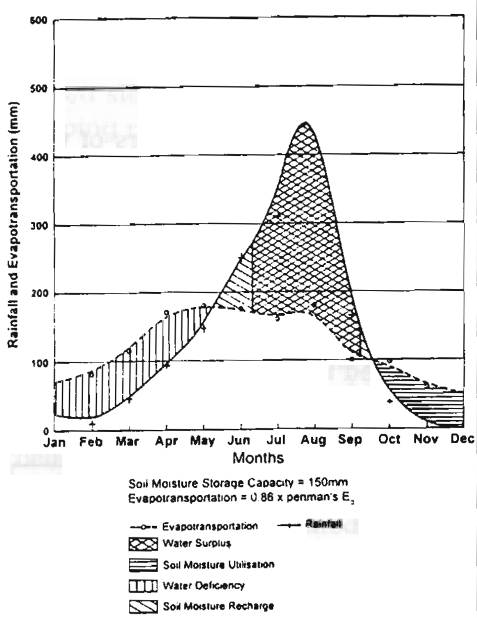

Figure 2: Average Water Balance Through the Year in Punyamati Catchment

The temperature of the water varied from 12.4 - 22°C. According to Waisel (1971), Rogers and Breen (1980), Sastroutomo (1981), Kadono (1982), and Chambers et al. (1985), the summer water temperatures below 25°C provide suitable conditions for both turion germination and formation of *P. crispus*. Turion germination and formation starts from May in the Panyamati River when water temperatures are around 22°C. Temperatures showed negative correlation with biomass production. Yadav et al. (1987) have also made similar observations.

The pH of water varied from 6.9 - 7.1 at station 1 and 6.9 - 7.2 at station 2. The water at station 2 was slightly alkaline. The conductivity ranged from 130-180μS/cm^{-1} at station 1 and 140-188μS/cm^{-1} at station 2. The high conductivity value at station 2 might have been due to the presence of a large amount of dissolved solids. The conductivity showed positive correlation with biomass production.

Transparency varied from 19.4-39.3 NTU at station 1 and 16.2-35.1 NTU at station 2. Water at both the stations was turbid in June-July. This has not only affected the rooting depth productivity and distribution, but it has also resulted in death and decay of the plant in order to enter the dormant period. Following the reduction in rainfall intensity, the transparency improved during the month of February, and this simultaneously helped the P. *crispus* to re-appear, either by perpetuating the old clump or by germinating the turions.

Dissolved oxygen (DO) ranged from 6-7.3 mg/L^{-1} at station 1 and 6-8.6mg/L^{-1} at station 2. The higher DO concentration was observed in winter, and this might be due to low temperatures, high atmospheric pressure, and greater water turbulence. On the other hand, low DO concentration in the rainy season might be due to the monsoon, resulting in the fast flow of water and simultaneous increase in the amount of silt loads and organic debris in the river. DO showed a positive correlation with the biomass production.

Biochemical oxygen demand (BOD) values ranged from 0.8-2.1mg/L^{-1} at station 1 and 1.0-6.9mg/L^{-1} at station 2. High BOD might have been due to a high amount of organic matter and high bacterial activities in the water. But, low BOD concentration in the rainy period might have been due to the high flow rate of water. BOD values showed positive correlation with biomass production.

Total hardness values ranged from 12.5-55mg/L^{-1} at station 1 and 12.5-63mg/L^{-1} at station 2. The value was maximum in summer and minimum in the rainy period, and this might have been due to a high flow rate and lower ca $^{++}$ and mg $^{++}$ concentration, respectively. Hardness of water had a positive correlation with biomass production.

The nitrogen-nitrite values ranged from 0.070-0.085mg/L^{-1} at station 1 and 0.014-0,082mg/L^{-1} at station 2. The N-nitrite concentration was found to have increased during summer, while it decreased during the rainy period, and this might have been due to the wash out of organic debris and dead clumps of *P. crispus*.

The Nitrogen-nitrate values at both stations ranged between 0.15 - 0.38mg/L^{-1}. The orthophosphate values ranged from 0.22 - 0.62mg/L^{-1} at station 1 and 0.22 - 0.60mg/L^{-1} at station 2. Orthophosphate showed a positive correlatiion with biomass production.

Coefficient of correlation (r) values between physico- chemical parameters and biomass of *Potamogeton crispus* L. at station 1 and station 2 are given in Table 1.

Table 1: Coefficient of Correlation (r) Values between Physico-chemical Parameters and Biomass of Potamogeton crispus L. at Station 1 and Station 2

Station 1		
Parameters		Correlation (r)
Physioco-chemical	P. crispus L. Biomass	
Temperature	Biomass	-0.59*
PH	Biomass	0.29
Conductivity	Biomass	0.49
Transparency	Biomass	0.88*
DO	Biomass	0.91*
BOD	Biomass	0.90
Total Hardness	Biomass	0.71*
N-Nitrite	Biomass	0.40
N-Nitrate	Biomass	0.02
Orthophosphate	Biomass	0.85*

Station 2		
Parameters		Correlation (r)
Physioco-chemical	P. crispus L. Biomass	
Temperature	Biomass	-0.10
PH	Biomass	0.77*
Conductivity	Biomass	0.72*
Transparency	Biomass	0.93*
DO	Biomass	0.17
BOD	Biomass	0.79*
Total Hardness	Biomass	0.65*
N-Nitrite	Biomass	0.10
N-Nitrate	Biomass	0.24
Orthophosphate	Biomass	0.73*
* Significant at 5% level of significance		

At station 1, the coefficient of correlation values with DO and BOD were found to be highly positive, i.e.,r=0.91 and r=0.90, respectively which are significant at a five per cent level of significance. While temperature showed a negative value, i.e.,r=-0.59, which is also significant at a five per cent level of significance. Moderately positive correlations were found with conductivity (r=0.49) and N-nitrite (r=0.40)which are significant at a five per cent level of significance, transparency (r=0.88) and Hardness (r=0.71), and Orthophosphate (r=0.85) which are significant at a five per cent level of significance. Similarly, low positive correlation was found with pH (r=0.29) and with N-nitrate, i.e.,r=0.02, which are insignificant at a five per cent level of significance.

At station 2, transparency showed a high positive correlation value, i.e.,r=0.93, which is significant at a five per cent level of significance. Similarly, values for pH, conductivity, BOD, Hardness and Orthophosphate were moderately positive, i.e., r=0.77, r=0.72, r=0.79, r=0.65 and r=0.73 respectively which are significant at a five per cent level of significance. Similarly low positive correlations were found with DO, N-nitrite and N-nitrate, i.e., r=0.17, r=0.10, and r=0.24 respectively, whereas correlation was negative with temperature (r= -0.10); these values are insignificant at a five per cent level of significance.

A detailed picture of the biomass of *P. crispus* is illustrated in Figures 3 and 4. Total biomass ranged from 9.59gm/M^{-2} in July to 71.66 gm/M^{-2} in March at station 1 while at station 2 it ranged from 37.36 gm/M^{-2} in July to 290.55 gm/M^{-2} in March. It was the most dominant plant during February and March, showing luxuriant growth. It started decreasing by the month of May. The total biomass of *P. crispus* was observed to be higher at station 2 than at station 1.

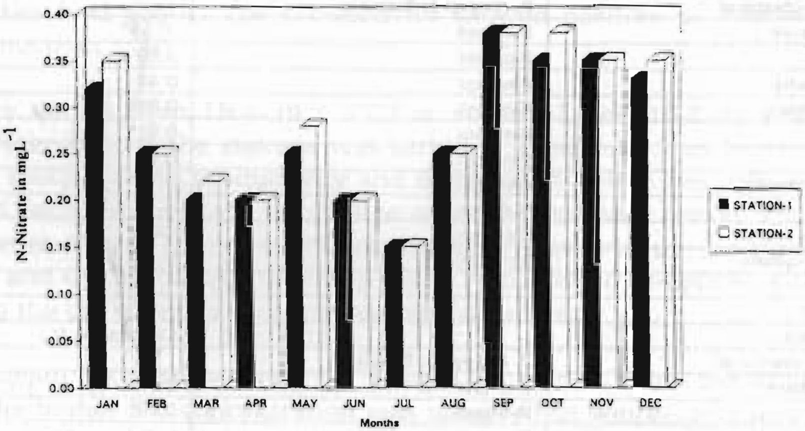

Figure 3: Seasonal Variations in N-nitrate (1993)

At station 1 41.4 per cent of maximum dry mass of underground stem was observed in July and a minimum of 15 per cent in October, while at station 2 the highest observed was 34.8 per cent in July and the lowest 16 per cent in November. The percentage dry mass of aboveground stem at station 1 ranged from 30.95 per cent in October to 42.75 per cent in July and at station 2 from

30.90 per cent in September to 45.18 per cent in July. The leaf biomass was highest (38.78%) in March and the lowest (16.03%) in July. At station 1 the percentage dry mass of turion ranged from 11.12 per cent in September to 1.56 per cent in July, while at station 2 it ranged from 12.49 per cent in September to 0.99 per cent in July.

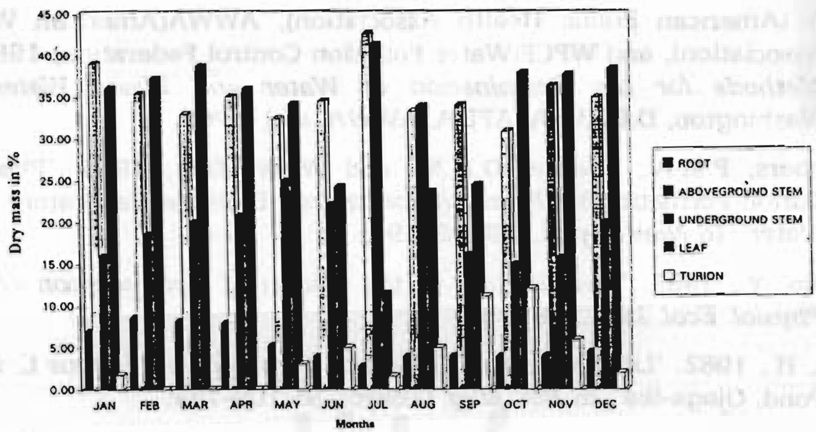

Figure 4: Seasonal Variations in Biomass Distribution among Each Part of Station 1 (1993)

At station 2, impoundment made of pipe bridge resulted in accumulation of silt and organic debris as well as increased depth, which simultaneously led to a significant increase in biomass of *P. crispus.*

Conclusion

The present study revealed at least four significant facts concerning clump maintenance and continuous growth of P. *crispus* in the river. First, the primary organ for clump maintenance in the river was the shoot itself and the turions which are less important than shoots. Second, continuous growth of shoots occured as successive regrowth from buried stems and rhizomes. Similar observations were of made by Kunii (1988) in Narutoh River, Japan. Third, river bed of silt and soil is more favourable for growth and clump maintenance than river bed with stones, pebbles, and sand. This condition was brought about in the river by cumulative effects of land-use pattern, water current, soil erosion, and upstream impoundment. Fourthly, deposition of sediment on the river bed was found to be advantageous in protecting plants from uprooting especially in mountainous rivers with seasonal high flow rates like the Punyamati. Sedimentation was also found to be favourable for regenerating new shoots from buried stems and rhizomes after recessions in flow rate. It can be concluded that turions in a lotic habitat play an important role, not in clump maintenance but rather in plant dispersal, since they are susceptible to current flow. From the overall result, it can be said that river beds with silty sand accumulation, with depths around 1-1.5m are most favourable for the growth and clump maintenance of P. *crispus,* if the physio-chemical parameters of the water lie within the range of those of the Punyamati River. It has also been observed that the impoundment increases silt accumulation upstream, assisting the collection and germination of turions for extensive growth of the plant in a lotic habitat.

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