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NET BIOMASS PRODUCTION, ENERGY AND NUTRIENTS OF *POTAMOGETON CRISPUS L.* IN UNPOLLUTED AND POLLUTED WATERS OF GANGA RIVER AT VARANASI, INDIA

Production nette de biomasse , teneur en substances nutritives et énergie par *Potamogeton crispus L.* dans les eaux polluées ou non du Gange à Varanasi, Inde

A.K.SHRIVASTAVA, R.S. AMBASHT & RAJU KUMAR*

RESUME

La pollution du Gange par la ville de Bénarès a pour effet d'augmenter la biomasse, l'énergie ainsi que les teneurs en N, P, K, Na, et Ca de P.crispus. Une augmentation significative de ces variables se produit au cours de l'hiver.La production primaire est toutefois plus basse que dans d'autres milieux intertropicaux.

ABSTRACT

Pollution of the Ganga waters by the Benares town induces increase of biomass, energy and N, P, K, Na and Ca contents of P. crispus. Those variables attain a maximum value during winter season. Nevertheless, primary production was here lower than in other subtropical habitats

INTRODUCTION

There is a general paucity of works on submerged macrophytes in rivers and streams (MADSEN & ADAMS, 1988) as compared to lakes. In rivers, macrophytes are of limited occurrence due to turbulence, water current and drastic seasonal rise and fall in water level. *Potamogeton crispus L.* is a submerged macrophyte which grows in diverse aquatic habitats of deep or shallow water lakes, ponds, lentic pools, lotic streams and sediment or mud bottoms. Pseudo-annual habit of *P. crispus* in stagnant water bodies and pools of several temperate regions was observed by YAMAGUTI (1944), WAISEL (1971), SASTROUTOMO *et al.* (1979), ROGERS & BREEN (1980), KUNII (1982),

* Centre for Advanced Study in Botany, Banaras Hindu University, Varanasi, 221005, India

TOBIESSEN & SNOW (1984), and CHAMBERS *et al.* (1985). Several workers have also noted its presence in many flowing streams (ARBER, 1920, SCULTHORPE, 1967 and KADONO, 1984).

Macrophyte productivity in aquatic system of temperate and tropical conditions was studied by PENFOUND (1956), EDWARD & OWENS (1960), WESTLAKE (1963, 1965), BELLAMY (1967), SAHAI & SINHA (1970), AMBASHT (1971), SINHA & SAHAI (1973), HUTCHINSON (1975), WETZEL (1975), PANDEYA & KAUL (1976) and KAUL (1977). Energy aspect of productivity in aquatic system was initiated by LINDEMAN (1942) through his classical work on Cedar Bog lake in U.S.A. DAVIS (1967) in his studies of aquatic ecosystem has regarded that the matter is in fact a vehicle for the flow of energy. There are a number of work on energy contents and energy relationships in different ecosystems (GOLLEY, 1961, 1965; LIETH, 1962, 1965; SRIVASTAVA & AMBASHT, 1989).Nutrient content of aquatic macrophytes has been studied by STAKE (1967, 1968), BERNATOWITZ (1969), BOYD (1969, 1978), KIMBALL & BAKER (1982), and SHARDENDU & AMBASHT (1991). However, comprehensive studies on growth, biomass production, net production associated with nutrient content are generally lacking in tropical condition, more so in aquatic macrophytes. We have therefore worked out the growth, biomass, energy content and nutrients (N, P, Na, K, and Ca) in *Potamogeton crispus.*

MATERIALS AND METHODS

Description of the study site

The Ganga river originates in the foothills of Himalayas in the northwest Uttar Pradesh in the Gangotri glacier and flows to 2500 km. The study has been carried out on Ganga river at Varanasi during 1986-87. Varanasi is located on 25°20' N latitude and 83°1' E longitude and it occupies a central position in the Gangetic plains. Two sampling points were selected on the city side of river. Site 1 (unpolluted) is situated in the upstream and is free from city sewage and other pollution loads and another Site 2 (polluted) in the downstream and receiving municipal sewage and ash from cremation of dead bodies through burning of wood carried out round the clock althrough the year (about 30 000 dead bodies are burnt at Varanasi annually). Macrophytes are presented only in small pockets, in this stretch of the river.

Methods

Standing crop biomass was measured by a vertical core sampler 25 x 25 x 50 cm. Harvested plant material was collected in polyethylene bags and brought to the laboratory. Plant samples were washed by tap water to remove adhering mud, silt and clay. Samples were oven dried at 80°C for 78 h and weighed for dry weight estimation. Dried samples were powdered and pressed into pellets of about 1g for energy estimation. Energy was estimated by Parr oxygen bomb calorimeter using the formula given by LIETH (1968).

$$V = (W \cdot \Delta t - \Sigma c) / G$$

Where, V = calorific value per gram of sample, W = water volume (1300 ml), Δt = corrected temperature difference, Σc = correction value for acid formed and for the ignition wire and G = dry weight of the sample.

Annual net production was computed from the positive difference of monthly dry weight biomass. Total nitrogen was estimated by the Kjeldahl digestion procedure, phosphorus by the chlorostannous reduced molybdophosphoric blue colour method (JACKSON, 1967). Sodium, potassium and calcium were estimated using Systronic Type 121 flame photometer with specific filter.

Two factor analysis of variance (ANOVA) between site and month was done to determine the significance of variation in biomass, energy and nutrient contents. The variation of biomass, energy and nutrient between site was tested at 5% level by calculating LSD (SNEDECOR & COCHRAN, 1967).

RESULTS

Biomass

The plants appeared first after recession of floods in September and during October 1986 the initial biomass recorded 12.62 at site l and 20.45 g m^{-2} at site 2 (Fig.1).

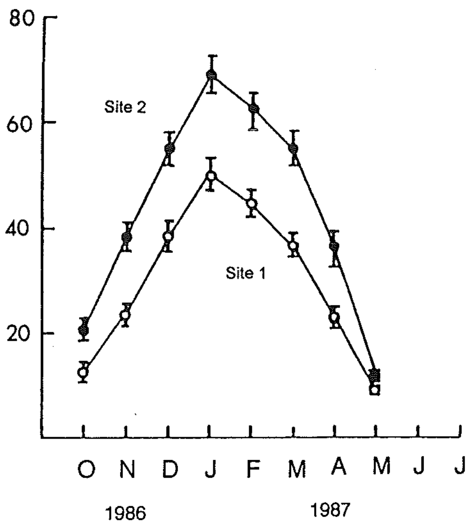

Fig.1. - Biomass of *Potamogeton crispus* (g.m^{-2}) at site 1 (-o-) and site 2. (-•-). Standard deviations at 0.05 level are indicated

Plants grew well during winter and attained the peak biomass of 50.46 at site 1 and 68.87 g m^{-2} at site 2 accompanied by the formation of inflorescence and turion during January. Leaf fall first occurred in late winter month of February and continued through May 1987 in summer season when the minimum value of 9.86 at unpolluted and 11.62 g m^{-2} at polluted site was observed. Winter season was most favourable for vegetative growth and average biomass for 8 months growth period was 30.04 at upstream site and 43.90 g m^{-2} at downstream site.

Energy concentration

Calorific value in J g^{-1} of 9 469 ± 444 during initial stage of growth at site 1 and 11 978 ± 457 at site 2 was estimated during October. Winter season favoured solar energy harvest due to well developed leaf lamina and stored most of the energy with a peak of 10 903 ± 558 J g^{-1} at site 1 and 12 809 ± 457 at site 2 during January. Senesced plant contained lowest energy concentration due to its release by different components and minimum energy of 9 351 ± 450 at upstream and 11 781 ± 511 J g^{-1} at downstream site was noted during May in summer season. Polluted site plants performed a better growth and energy content than plants of the unpolluted site. This may be due to lesser anthropogenic activities and some nutrients enrichments from the sewage (Tab. I).

Net production

Annual net production of *P crispus* in 8 month growth period was 50 g m^{-2} at unpolluted site in which October month (rainy season) contribution of 13, and of winter

Tab.I. - Energy concentration (J g^{-1}) of *P.crispus* at site 1 and site 2 of River Ganga. Values are means and S.D.

Months	Site 1	Site 2
October	9 469 ± 444	11 978 ± 457
November	10 247 ± 406	12 322 ± 464
December	10 654 ± 365	12 404 ± 441
January	10 903 ± 558	12 809 ± 457
February	10 769 ± 455	12 585 ± 510
March	10 339 ± 537	12 383 ± 606
April	9 919 ± 550	12 200 ± 578
May	9 351 ± 450	11 781 ± 511

(November-February) season 37 g m^{-2}. At polluted site, annual production of 69 g m^{-2} was observed in which October production was 20.5 g m^{-2} $month^{-1}$ and winter of 48.5 g m^{-2} for 4 months. Production was negligible in late winter and summer seasons due to senescence of plant part and successive decrease in biomass value (Fig. 2).

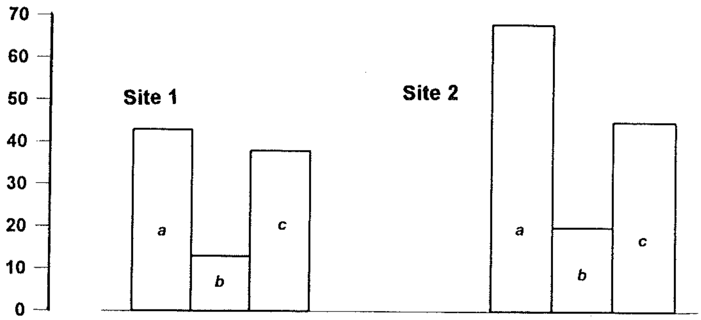

Fig.2. - Primary production of *Potamogeton crispus* (g. m^{-2}) during different seasons at site 1 and site 2. a.-net annual; b.- production in rainy season (October month); c.-production of winter season (November to February).

Nutrient concentration

Different nutrient had their maximum and minimum values in different month during the study period (Tab. II). Peak value of nitrogen was observed in May at both the sites,phosphorus in January at unpolluted site and in May at polluted site, sodium during March at both the sites, potassium in December at site 1 and in May at site 2, and calcium in February at both the sites. Minimum value of nutrients was in different months at upstream site, while during October in downstream site.

Tab.II. - Monthly variations in nutrients concentration (%) of *P.crispus* at site 1 and at site 2 of river Ganga

	Site 1					Site 2				
	N	P	Na	K	Ca	N	P	Na	K	Ca
Oct	2.10	0.13	0.48	2.62	1.00	2.10	0.16	0.39	3.01	1.00
Nov	2.22	0.15	0.52	2.95	1.03	2.40	0.18	0.58	3.25	1.04
Dec	1.98	0.16	0.52	2.99	1.25	2.42	0.18	0.59	3.36	1.39
Jan	1.86	0.16	0.54	2.87	1.51	2.47	0.19	0.61	3.21	1.65
Fev	1.87	0.13	0.53	2.79	1.52	2.38	0.19	0.62	3.18	1.72
Mar	1.89	0.14	0.54	2.91	1.23	2.40	0.21	0.62	3.20	1.39
Apr	2.10	0.15	0.54	2.98	1.12	2.47	0.24	0.60	3.27	1.32
May	2.23	0.13	0.53	2.05	0.98	2.58	0.29	0.60	3.46	1.14

Nutrient content

Most of the nutrients had maximum value during January at both sites. The respective values in g m^{-2} for site 1 and site 2 were 0.94 and 1.70 of nitrogen, 0.08 and 0.13 for phosphorus, 0.27 and 0.42 for sodium, 1.45 and 2.21 for potassium and 0.76 and 1.14 for calcium. The lowest nutrient content was in May. The respective site 1 and site 2 values in g m^{-2} were 0.22 and 0.30 of nitrogen, 0.01 and 0.03 of phosphorus, 0.05

and 0.07 of sodium, 0.02 and 0.40 of potassium. The calcium content, however, showed lowest in October being 0.13 and 0.20 g m^{-2} (Fig. 3).

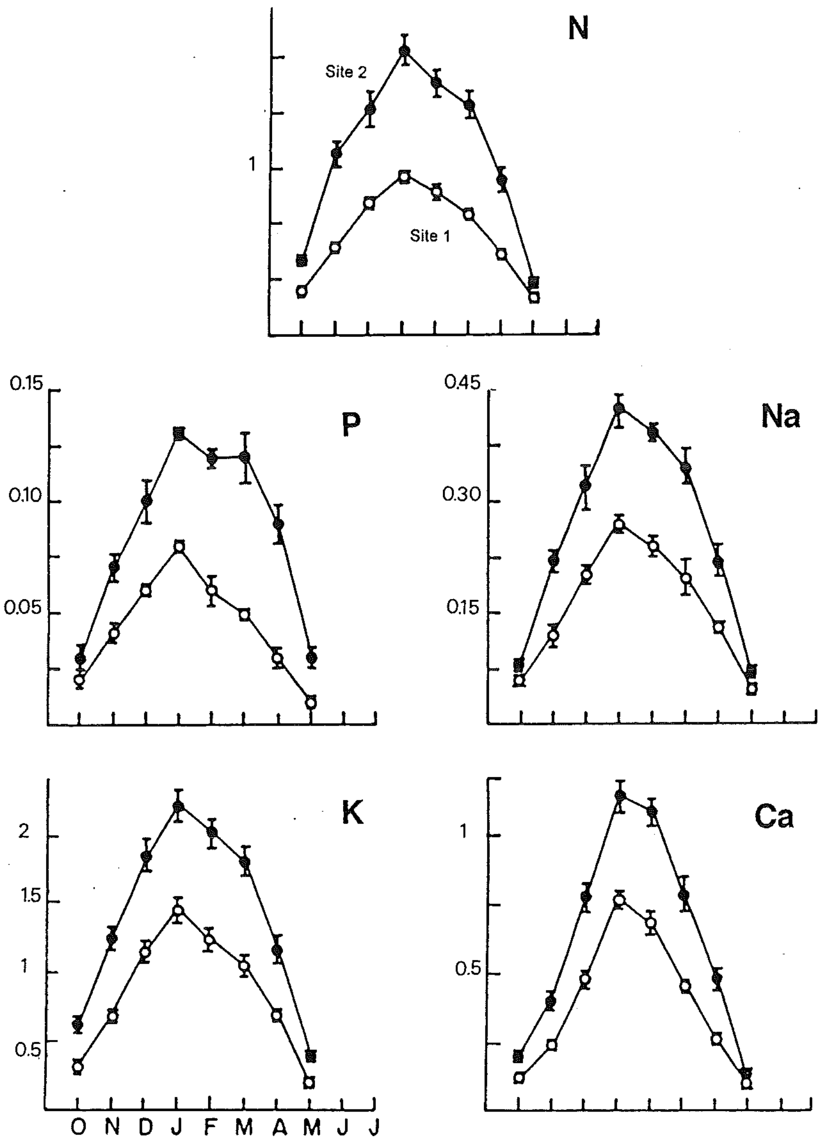

Fig.3. - Nutrient content of *Potamogetum crispus* at site 1 (-o-) and site 2 (-•-). Standard deviations at 0.05 level are indicated.

DISCUSSION

Germination of aquatic macrophytes is influenced by a series of factors. Importance of photon density, quality and temperature were studied by GUPPY (1897), FORSBERG (1965), WETZEL & McGREGOR (1968), SHARMA & GOPAL (1978), VAN VIERSEN (1982), VAN VIERSEN & VAN WIJK (1982) and VAN WIJK (1988) in regulating germination of aquatic plant. Total macrophyte biomass and species composition gives us an integrated picture of the growth cycles and physiological responses of several species which occur in the same habitat but separated temporally and spatially.

Tab. III. - Two factors analysis of variance (ANOVA) (site-wise, monthwise,and site-month interaction) for biomass, energy and nutrient (N, P, Na, K & Ca) of *P. crispus*. *F values*

	Site	Month	Site-month interaction
Biomass	129.12 **	105.45**	3.24^{NS}
Energy	184.93**	82.11**	4.58*
Nitrogen	282.13**	93.77**	9.46**
Phosphorus	372.42**	96.36**	8.98**
Sodium	195.92**	111.99**	7.88**
Potassium	215.99**	103.66**	4.01**
Calcium	175.31**	153.86**	7.53**

Significant at: * $P < 0.025$, ** $P < 0.005$; NS = not significant.

P. crispus attained maximum biomass during winter season.This was due to calm river current, favourable temperature and good quality of light. Submerged aquatic plants have reduced root system and most of the growth and production are dependent on the trophic status of water. The plants of site 2 contained a slightly higher biomass may be due to nutrient enriched river water. Site wise variation in biomass of *P. crispus* was significant at $P < 0.05$. Monthly variation was also significant at $P < 0.005$, while site and month interaction was not significant (Tab. III).

Energy concentration of *P. crispus* was highest during winter when most of the new plants emerged and mature plants attained peak biomass. Similar observation was noticed by JHA (1968), SRIVASTAVA (1973), and VERMA (1979) in his doctoral work. Lower energy during summer season was obtained due to unfavourable scorching temperature and senesced leaf. The caloric value of plant material depends upon the nature and quantity of food reserves present in its body. Fats, carbohydrates and proteins are chief energy storage components in the plant and these vary with age and season. Seasonal changes in the above constituents of some aquatic macrophytes and variation in energy were reported by BOYD & BLACKBURN (1970) .

Primary production in the present study was lower than the values obtained by ODUM (1957) in certain subtropical habitats (1000 g m^{-2} yr^{-1}), WESTLAKE (1963) in the fertile sites in U.K.(400-700 g m^{-2} yr^{-1}), SAHAI & SINHA (1976) for Ramgarh lake (198 g m^{-2} yr^{-1}) and by KAUL *et al.* (1978) for Dal lake (220-276 g m^{-2} yr^{-1}).

Seasonal, structural and spatial differences in the macrophyte nutrients have been studied by GERLOFF & KROMBHOLTZ (1966), BOYD (1969), HUTCHINSON (1975), and KIMBALL & BAKER (1982, 1983), even among plants of the same family at the same site. In this study, similar seasonal and site wise differences in the nutrients has been observed. The average nutrient content of 0.59 N, 0.04 P, 0.16 Na, 0.86 K and 0.39 g m^{-2} of Ca at site 1 and 1.07 N, 0.09 P, 0.26 Na, 1.40 K and 0.62 Ca g m^{-2} at site 2 was lower than that of 5.4 N, 0.28 P, 4.3 K and 5.6 Ca g m^{-2} average values of Anchar lakes (KAUL *et al.* 1980) and 0.48 Na g m^{-2} at Dal lake (KAUL *et al.* 1980). Site 2 plants have high nutrient content than of site 1. Nutrients (N, P, Na, K and Ca) of *P crispus* showed significant variation $P < 0.005$ between site, between month and between site and month interaction (Tab. III).

From the foregoing observations it is noticed that *Potamogeton crispus* is easily capable of growing well in moderately polluted zones of Ganga river at anthropogenically one of the most severely influenced regions.

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