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ACKNOWLEDGEMENTS. Financial support from the Department of Biotechnology and the Union Ministry of Environment & Forests, Govt of India is gratefully acknowledged. We thank Dr Anil Kumar for help in photography.

Received 25 February 2002; revised accepted 11 June 2002

Effect of fire on nutrient dynamics in a semi-arid grazing land ecosystem of Madurai

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This study deals with the effect of fire on the nutrient dynamics of a grazing land in the semi-arid region of Madurai. The nutrient concentrations were maximum in the live shoot followed by below-ground parts, dead shoot and litter. The various nutrients accumulated in the plant components of the burned grazing land were in the order of N > K > Ca > Mg > P, whereas in the unburned site the nutrients were accumulated in the order of N > Ca > K > Mg > P. Except potassium, all the nutrients were higher in the unburned than in the burned grazing land. The uptake of nutrients from the soil was significantly higher ($P < 0.05$) in the unburned grazing land than in the burned grazing land. Of the total uptake, a larger amount of nutrients was transferred to above-ground parts than below-ground parts. In both the sites, the amount of nutrients returned to the soil through below-ground parts was more than through above-ground litter decomposition. The input to output nutrient ratio showed that burning of vegetation accelerates nutrient cycling.

GRASSLANDS are influenced by various biotic stresses such as grazing, mowing and fire. These stresses have tremendous impact in shaping or altering the vegetation. Fire alters the physical and chemical properties, organic and mineral reserves[1] and the microbial population of the soil[2]. The effects of fire on the nutrients of an ecosystem depend on the type and frequency of fire, the fuel load, time and season of burn, nature of the plant tissues burnt, topography, successional status of the community and post-fire climatic and biotic conditions acting thereupon[3,4]. A fire of mild intensity may stimulate high seedling establishment and growth by raising the soil temperature and nutrient status by removal of plant litter and vegetation cover[5]. As a result of fire, the availability of nutrients for plant uptake increases or they can be volatilized and lost from the site. Burning of vegetation has been used as a management practice to improve the productivity of an ecosystem. There are many reports available on forest fires[6,7]. However, reports on tropical grassland fires are scanty. The objective of the experiment was to study the effect of fire on nutrient dynamics of grazing land in the semi-arid region of Madurai.

The study was conducted at Madurai which is located at 10°00′N latitude and 78°10′E longitude. The climate of Madurai is semi-arid. The mean maximum temperature ranges from 28.2 to 37.4°C and the mean minimum temperature ranges from 20.5 to 28.3°C during the study period. Total annual rainfall during the study period was 1061 mm and the relative humidity ranged from 33 to 79%. The soil is a reddish-brown, laterite sandy loam of recent origin. The mean monthly pH of the soil ranged from 7.0 to 7.9 in the unburned site and 7.3 to 8.3 in the burned grazing land during the study period. *Heteropogon contortus* is the major dominant species of the grasslands. An area of about 0.2 ha of the grassland was intentionally burned on 25 May 1993. The adjacent unburned area of grassland of 0.25 ha was kept as control for the present study. The experiment was carried out for one year during July 1993 to June 1994.

The biomass was estimated by harvest method[8]. The vegetation was harvested at monthly intervals from ten randomly laid quadrats, each of 0.5 m^2. The plant

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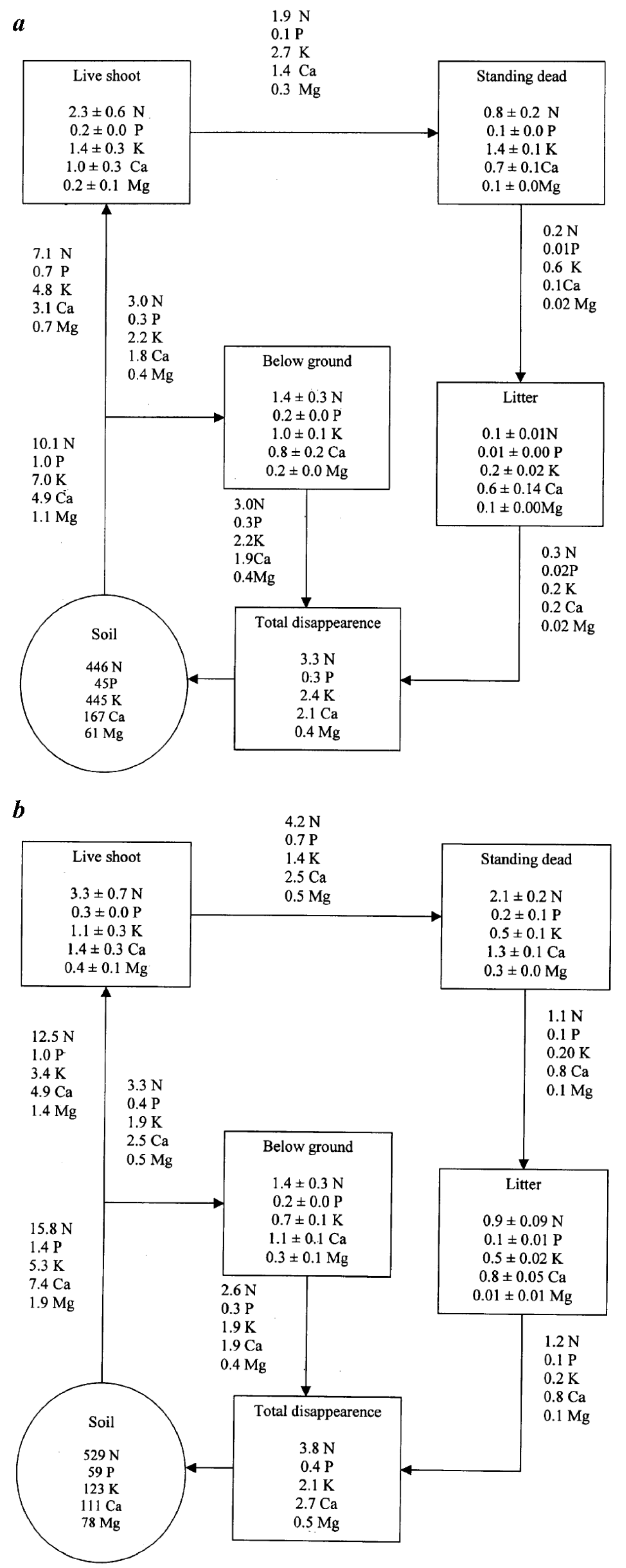

Figure 1. ***a***, Uptake, transfer and release of nutrients in the burned grazing land. Values in the compartments are mean standing crop of nutrients (g m^{-2}) and those on arrows are net annual flux rates (g m^{-2}). ***b***, Uptake, transfer and release of nutrients in the unburned grazing land. Values in the compartments are mean standing crop of nutrients (g m^{-2}) and those on arrows are net annual flux rates (g m^{-2}).

material was separated into live and dead shoots. The litter from each harvested quadrat was collected separately. The below-ground biomass was estimated by excavating 25 cm × 25 cm × 30 cm monolith from three randomly laid quadrats. The roots were separated by washing the soil with water using a 2 mm sieve. All plant material was oven-dried at 80°C till constant weight. The total nitrogen and phosphorus contents of both soil and plants were analysed using an autoanalyser (Grad Ko International Ltd, UK). Potassium, calcium and magnesium concentration were estimated using an atomic absorption spectrophotometer[9] (Perkin-Elmer, Model 5000). The nutrient content of each component was calculated by multiplying concentrations with respective dry mass. The nutrient content of dry soil (0–30 cm depth) was multiplied by the bulk density and the results are expressed in g/m^2. The transfer of nutrients between various compartments and the release of nutrients through root and litter disappearance were calculated following Singh and Yadava[10]. The sum of root and litter disappearance was considered as total release of nutrients by vegetation. The difference between total uptake and release was considered as retention. Student's *t* test was used to study the significant differences between the sites.

Tissue nutrient contents were maximum in the live shoot components followed by below-ground parts, dead shoots and litter (Table 1). The decline in the nutrient content as plant material moves to litter stage is due to weathering or leaching of respective elements by rain interception or translocation before moving into the dead stage[11,12]. Similar decrease in nutrient content was observed by Gupta *et al.*[13] and Karunaichamy and Paliwal[14]. The various nutrients accumulated in the plant components of the burned grazing land were in the order of N > K > Ca > Mg > P, whereas in the unburned site the nutrients were accumulated in the order of N > Ca > K > Mg > P. Except potassium, all the other nutrients were higher in the unburned grazing land than in the burned grazing land. Fire may cause direct losses through the transfer of nutrients to the atmosphere as gases and particulates[15], while indirect losses may result from erosion of ash and soil during storms[16]. In the present study the nitrogen content was higher in the unburned site than in the burned one, suggesting that N is volatilized during burning of vegetation[17]. Several studies have documented large losses of nitrogen during fires due to volatilization[18,19]. The decrease in nitrogen may also lead to loss of soil microflora and fauna which are essential for growth and development of higher plants[20]. The potassium content was higher in the plant components of burned grazing land. Similar increase in potassium content was also observed by Bhandari *et al.*[21] in Garhwal Himalaya.

The uptake, transfer and release of nutrients in various plant components of the burned (Figure 1 *a*) and unburned (Figure 1 *b*) grazing lands are shown in a block

Table 1. Average percentage nutrient contents (± SE) of various plant components of the grazing lands (July 1993–June 1994) expressed on oven dry weight basis. Values in parentheses are nutrient contents of the unburned grazing land

Plant component	N	P	K	Ca	Mg
Live shoot	1.05 ± 0.037 (1.41 ± 0.041)	0.07 ± 0.005 (0.10 ± 0.006)	0.54 ± 0.024 (0.45 ± 0.027)	0.45 ± 0.023 (0.48 ± 0.027)	0.10 ± 0.008 (0.14 ± 0.007)
Dead shoot	0.47 ± 0.010 (0.56 ± 0.034)	0.06 ± 0.005 (0.06 ± 0.007)	0.38 ± 0.016 (0.34 ± 0.017)	0.36 ± 0.010 (0.36 ± 0.010)	0.09 ± 0.005 (0.09 ± 0.003)
Litter	0.31 ± 0.048 (0.46 ± 0.017)	0.03 ± 0.005 (0.06 ± 0.004)	0.26 ± 0.039 (0.23 ± 0.015)	0.20 ± 0.030 (0.33 ± 0.008)	0.05 ± 0.005 (0.09 ± 0.005)
Below-ground	0.58 ± 0.052 (0.61 ± 0.047)	0.06 ± 0.004 (0.07 ± 0.004)	0.39 ± 0.021 (0.37 ± 0.016)	0.34 ± 0.019 (0.42 ± 0.020)	0.08 ± 0.010 (0.08 ± 0.005)

and arrow model. The uptake of nutrients (except K) was significantly higher ($P < 0.05$) in the unburned site than in the burned site. From the total uptake a larger amount of nutrients was transferred to above-ground parts than below-ground parts. Greater accumulation of nutrients in the live shoots is a characteristic feature of tropical grasslands[10,22]. The amount of nutrients absorbed from the soil and then released through litter and roots in these grazing lands was comparatively higher than in temperate grasslands[23]. In both the sites, the amount of nutrients returned to the soil through below-ground parts was more than through above-ground litter decomposition during the study period. Nutrient output to input ratios give an indication of nutrient use efficiency. In this study, burning stimulates nutrient use efficiency. It is concluded that burning of vegetation accelerates nutrient cycling through rapid release.

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ACKNOWLEDGEMENT. We thank the Ministry of Non-Conventional Energy Sources, Government of India for financial assistance.

Received 25 February 2002; revised accepted 9 May 2002

Late Quaternary peat deposits from Vembanad Lake (lagoon), Kerala, SW coast of India

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Vembanad lagoon is the largest backwater system on the Kerala coast and acts as a major depocentre for Quaternary deposits. Peat deposits have been identified at different depths in the boreholes between sandy clay and clayey sand sedimentary facies. These peat deposits gave a radiocarbon age of 40,000 yrs BP. Pollen analysis of peat revealed the existence of mangrove vegetation and evergreen forest, suggesting humid climate during that time. Presence of desiccated clays beneath the peat deposits suggests arid climate prior to the humid climate during 40,000 yrs BP.

THERE is an extensive estuarine system of backwaters on the southwest (Kerala) coast of India, of which the Vembanad lake/lagoon is the largest, extending 80 km in

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