Effect of winter fire on primary productivity and nutrient concentration of a dry tropical savanna

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Abstract

Burning increased the mean annual canopy and belowground biomass of a dry tropical savanna by 40\% and 12\%, respectively, while littermass was reduced by 85\% in comparison to control savanna. Mean annual aboveground and belowground net primary production were 471 and 631 g m\(^{-2}\) in control, and 584 and 688 g m\(^{-2}\) in burned savanna, respectively. Fire caused an increase in mean aboveground net production of 24\% and in belowground net production of 9\%.

Concentration of carbon, nitrogen and phosphorus in vegetation of unburned plots ranged between 34.01-38.59\%, 0.85-1.53\% and 0.04-0.11\% and in soil from 0.95-1\%, 0.011-0.13\% and 0.017-0.02\%, respectively. Fire increased the mean concentrations of N and P by 16\% and 42\% in vegetation and 18.18\% and 17.65\% in soil, respectively. Thus winter fire can be an important tool for the management of dry tropical savanna with respect to biomass production and nutritive quality.

Nomenclature: Verma et al. 1985

Introduction

Tropical grasslands and savanna account for about 1.05 \times 10\(^{10}\) tons of organic matter production (Lieth 1975), and rank second in contributing to total global net primary production (Lauenroth 1979). Fire is so intimately associated with these systems that many people consider all tropical savanna as fire climax (Gillon 1983). Fire exerts a controlling influence on primary production (Old 1969; Rice & Parenti 1978; Knapp 1984, 1985) and dynamics of plant communities (Trebauud & Lepart 1980). For example, the maintenance of North American tallgrass prairie before European settlement was largely due to the occurrence of fire (Hulbert 1973); both natural and man-induced (Pyne 1986). In absence of fire, litter accumulates, plant production decreases and woody species invade (Bragg & Hulbert 1976; Abrams et al. 1986; Knapp & Seastedt, 1986).

Fire in addition to the damage to plants and alternation to physical environment also change considerably the chemical status of the grassland community (Lloyd, 1971). Increase in plant quality is one of the main reasons for the frequent burning of moist savanna grasslands by man during the dry season (Frost & Robertson, 1987). In Britain, Allen (1964), Allen et al. (1969) and Lloyd...
(1971) have investigated the chemical aspects of fire in ericaceous grassland communities. There have been few attempts to document its long-term effect.

The long term (100 yrs) model of Ojima et al. (1989) favourably compared with the data of tallgrass prairie and showed that annual burning in late spring (April) accelerates production with increase in inorganic P, N-fixation, N-use efficiency and conservation of available N on one hand and decrease in soil C and N inputs on the other.

The present study deals with the effects of winter fire on plant biomass, net primary productivity and nutrient concentration in plants and soil in a dry tropical savanna.

Materials and methods

Study site

The experimental site is located on the Vindhyan plateau in Sonbhadra district of Uttar Pradesh, India at 24°36’36”N lat and 83°3’18”E long at 299 m above the mean sea level. Parent rocks are metasedimentary haematic slates together with banded jaspers, and quartzites with hornblende (Raychaudhuri et al. 1963). The soil is residual Ultisol and sandy loam in texture.

Climate is seasonally dry tropical. Mean maximum temperature varies from 23.2 °C in January to 40.5 °C in May and mean minimum from 13.3 °C in January to 30.5 °C in June (Fig. 1). The year is divisible into three seasons: summer (April–June), rainy (July–September) and winter (November–February). October and March constitute transition months between the rainy and winter season, and between the winter and summer season, respectively. The mean annual rainfall is 1035 mm of which 85% occurs in the rainy season. There is an extended dry period of about 9 months in the annual cycle.

The potential natural vegetation of the study region is a dry deciduous forest with or without Shorea robusta (Champion & Seth 1968). Adina cordifolia, Lagerstroemia parviflora, Hardwickia binata, Butea monosperma, Acacia catechu are the most frequent components. The tree species in the savanna are L. parviflora, H. binata, A. catechu and Diospyros melanoxylon with average density of 180 stems/ha. The savanna has been derived from dry tropical forest through anthropogenic forcing and is maintained at this stage by burning and grazing (Pandey & Singh 1991). The herbaceous vegetation at the site was dominated by perennial grasses Chrysopogon fulvus, Bothriochloa pertusa and Heteropogon contortus which contributed between 43.6–60%, 22.3–27.0% and 9.8–13.2%, respectively to the peak live shoot biomass (Pandey 1990). Mean per cent contribution by other species was 12%.

The site was fenced by the State Forest Department in 1979 to exclude grazing. Each year in November–January, the herbaceous vegetation, which at that time consists mainly of dead shoots, is harvested to avoid building up of fuel load. Six homogeneous sub-plots (20 × 10 m) were selected for the study and marked in the field. Three of these six plots were burned in the first week of January 1988 and again in the last week of November 1988 to emulate a traditional management system of annual burning. The treatments were set-up in a randomized block design.

The shoot biomass was harvested close to the ground level, from 3 randomly selected 50 × 50 cm