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SHORT-TERM EFFECT OF SEASONAL BURNING ON CARBON-NITROGEN (C/N) RATIO OF SOIL IN A *DICHANTHIUM ANNULATUM* GRASSLAND STAND AT VARANASI*

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The paper presents the C/N ratio of soil at the three different depths, viz. 0–10 cm, 10–20 cm and 20–30 cm of a protected *Dichanthium annulatum* grassland stand subjected to varying frequency of burning. The stand was divided into three plots of which plot I was burnt twice (on 30th January and 30th May, 1970), plot II only once (on 30th January, 1970) and plot III was left as unburnt. Burning brings about a decrease in carbon nitrogen ratio of the top layer of the soil. The ratio becomes wider at middle depth (10–20 cm) after the summer season and continues to be so till the end of the year. The extent of decrease in C/N ratio was higher in the plot that was burnt twice than in the plot burnt only once. The lowest soil depth (20–30 cm) was least affected by fire.

INTRODUCTION

The variation in carbon-nitrogen ratio of the soil is determined by the climatic factors, especially precipitation and temperature, and activities of micro-organisms. The ratio tending to become narrower leads to the formation of nitrates whereas a wide ratio causes nitrate depression. In fact, availability of nitrogen following the turning into the soil of organic materials is a matter of carbon-nitrogen ratio (Thomson & Harper, 1926). In most works, fire does not figure amongst the soil-forming factors, although it is one of the important components of the environment in terrestrial ecosystems. Burning may significantly affect the C/N ratio of the soil. In order to estimate the effect of fire on C/N ratio, the author studied the carbon and nitrogen contents of the soil collected from three different depths, viz. 0-10 cm, 10-20 cm and 20-30 cm followed by controlled burning in *Dichanthium annulatum* grassland at Varanasi.

The Study Site

The grassland stand of 50 × 25 m size dominated by *Dichanthium annulatum* and situated in the Botanical Garden of Banaras Hindu University, Varanasi, was selected as the study site. Topographically the ground is flat and the mean

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height from the sea level is approximately 76 m. Geographically the area is sub-tropical but hot summers modulated by monsoon and short winter give it a tropical character. The year is conveniently divided into three distinct seasons, viz. winter (November to February), summer (March to June) and rainy season (mid-June to early October). The mean maximum temperature ranges from 23.75 °C in January to 42.97 °C in May, and the mean minimum temperature is 28.11 °C in May and 9.25 °C in December. Relative humidity recorded at 8.00 a.m. range from 64% in dry season to 93% in rainy season. Total annual rainfall during the year of study (1970) was 759.80 mm of which 86 4% was received in the rainy season only.

Materials and Methods

(a) Burning

The study site was divided into three equal subplots, numbered I, II and III. Four permanent quadrats of 1 × 1 m size were marked with nails at random in each subplot. An area 2 meters wide around each quadrat was left intact. The vegetation around the intact area was denuded by scraping for 1 m width. An iron rod was wrapped with cloth and soaked in kerosin oil. This was lit and with the help of its flame, quadrats with surrounding vegetation of 2 m were burnt in the plots I and II on 30th January, 1970. Fire was set at one or two places on the margins which spread over the ground surface since the vegetation was nearly dry and it consumed all the standing crop. Unburnt plot III served as control. The plot I was again burnt on 30th of May in the same way. It was not possible to measure the intensity of fire. The ash remained mostly struck on the rough ground due to protection offered by the surrounding vegetation and light shower within a few days after burning.

(b) Sampling

Soil samples from three different depths, i.e. 0-10 cm, 10-20 cm and 20-30 cm were collected from the 2 meters area around the quadrats from each subplot at monthly intervals over one year period following burnings. The soil was air dried and root segments were sorted out.

(c) Chemical Analysis

(i) The soil nitrogen was estimated by macro-kjeldahl method (Piper, 1944) and the organic carbon of soil was determined by oxidizing the organic matter with nascent oxygen liberated from potassium dichromate as described by Misra (1968).

Results

The first burning brought about 13.0 % and 15.3 % decrease in C/N ratio in the surface soil (0-10 cm) during February in the plots I and II respectively as compared

TABLE I

The values for C/N ratio in the soil at three different depths in D. annulatum *grassland during the year* 1970

Months	Soil depths								
	0-10 cm			10-20 cm			20-30 cm		
	Plot I	Plot II	Plot III	Plot I	Plot II	Plot III	Plot I	Plot II	Plot III
Jan.	—	—	17·6±·6	—	—	12·7±·8	—	—	10·4±·2
Feb.	15·3±·4	14·9±·1	17·0±·8	12·2±1·0	11·8±·1	12·7±2·4	10·7±·1	10·4±·5	10·4±·2
Mar.	13·5±·8	13·3±·1	17·2±·2	13·7±·0	13·6±·1	13·2±·5	11·5±·2	11·1±1·0	10·9±·2
Apr.	11·3±·6	10·9±·2	17·5±·5	12·9±·6	12·7±·5	12·2±·2	10·6±·2	10·6±·5	11·1±·5
May	10·5±·1	10·7±·2	16·5±·5	10·8±·1	11·2±·1	12·1±·4	10·6±·5	10·6±·4	11·1±·2
June	9·1±·1	10·4±·3	16·0±·5	9·8±·3	10·4±·2	11·6±1·7	10·6±·2	11·0±·6	10·4±·5
July	11·5±·1	12·9±·6	17·7±·4	14·7±·2	14·1±·1	12·9±·4	10·0±·5	11·8±·1	12·5±·4
Aug.	12·8±·1	14·9±·2	17·3±·2	15·4±·3	14·8±·3	13·8±1·0	14·7±·3	13·3±1·0	14·1±·1
Sept.	12·2±·1	14·3±·2	16·2±·4	15·0±·4	14·3±·3	13·2±·7	13·4±·1	12·3±·1	12·8±·4
Oct.	11·2±·5	13·9±·3	16·4±·2	15·3±·0	14·1±·7	12·8±·5	13·2±·4	11·8±·2	11·7±·6
Nov.	10·7±·1	13·5±·2	16·7±·5	14·4±·3	13·2±·3	12·5±·3	12·1±·8	11·1±·5	11·3±·3
Dec.	11·1±·6	14·6±·2	17·3±·1	14·7±·6	13·2±1·8	12·3±·2	12·3±·8	11·1±·2	11·4±·1

Plot I Burnt on 30th January and 30th May 1970
Plot II Burnt on 30th January 1970
Plot III Unburnt control

with that of the plot III (Table I). The lower depths remained almost unaffected. During March a slight increase in ratio was obtained at lower depths in each plot but from April onward the values consistently decreased till June. The values at top soil also decreased regularly till June in all the three plots. The extent of reduction in ratio was 40.5% in the plot I, 30.2% in plot II and 5.8% in plot III during June at the surface as compared with the corresponding figures in February. The values at the middle depth showed a decrease of 28.4%, 23.5% and 12.1% in the I, II and III plots respectively over the values obtained in March. The lowest depth showed only a slight decrease. The values of June in the plots I and II when compared with those of the plot III respectively showed a decline of 43.7% and 35.1% at the surface soil and 15.5% and 10.3% at the middle depth (Table II). The decrease in ratio in plot I was higher after the second burning (Table II).

TABLE II

Increase and decrease in C/N ratio of burnt plots at three depths expressed as percentage of the C/N ratio of the unburnt plot

Months	Soil depths					
	0-10 cm		10-20 cm		20-30 cm	
	Plot I	Plot II	Plot I	Plot II	Plot I	Plot II
Jan.	—	—	—	—	—	—
Feb.	−10·0	−12·3	− 3·9	− 7·0	+ 2·8	−0·0
Mar.	−21·0	−22·2	+ 3·7	+ 3·0	+ 5·5	+1·8
Apr.	−35·4	−37·7	+ 5·7	+ 4·0	− 4·5	+4·5
May	−36·3	−35·1	−10·7	− 7·4	− 4·5	−4·5
June	−43·1	−35·0	−15·5	−10·3	− 1·9	+5·7
July	−35·0	−27·1	+13·9	+ 9·3	−20·0	−5·6
Aug.	−25·1	−12·8	+11·5	+ 7·2	+ 4·2	−5·6
Sept.	−24·6	−11·7	+13·6	+ 8·3	+ 4·6	−3·9
Oct.	−31·7	−15·2	+19·5	+10·1	+12·8	+0·8
Nov.	−35·9	−19·1	+15·2	+ 5·6	+ 7·0	−1·7
Dec.	−35·8	−15·6	+19·5	+ 7·3	+ 7·8	−2·6

With the onset of rainfall an increase was observed in C/N ratio at each depth of all the three plots. The values recorded during August were higher as compared with June values. A comparison of the values obtained in August for surface soil in the plots I and II with that of the plot III shows that there was a decrease of 26.0% in plot I and 13.8% in plot II whereas the C/N ratios in 10-20 cm soil depth for the plots I and II increased by 11.5% and 7.2% respectively. The lowest depth showed negligible fluctuation. During winter the ratio showed more or less a decreasing trend at each depth in all the three plots. During

Discussion

December, that is after one year of burning, the top soil layer of the plots I and II showed a decreased C/N ratio as compared with unburnt plot. In case of middle and lowest soil depths, however, slightly higher values for C/N ratio were generally recorded in burnt plot (Table II). The extent of decrease in December was higher in plot I than in plot II.

The high temperature created during the first burning reduces the carbon and nitrogen concentrations at the surface soil in the burnt plots as compared with those of the unburnt plot during February (Pandey, 1971). The percentage decrease in the amount of carbon was 1.09 and 1.3 times higher in comparison to that of nitrogen in the plots I and II respectively. The improportionate decline in the carbon and nitrogen concentrations yields a moderately narrow C/N ratio. Similarly, Issac & Hopkins (1937) reported a decrease in carbon-nitrogen ratio immediately after fire in forest soil of western Washington. The amount of carbon and nitrogen increased in March at each depth in all the three plots. This is the result of a heavy rainfall on 10th and 20th February, creating higher moisture content of the soil that accelerates the microbial activity for the decomposition of organic matter and nitrogen fixation in the soil. The concentration of carbon in the burnt plots exceeded that of the control plot at 10-20 cm soil depth and the same was true for nitrogen in the top soil. This resulted in a decrease of C/N ratio at the surface layer of soil and an increase at the lower depths in the burnt plots. The control plot showed a slight increase in the ratio at each depth.

Summer is characterized by high temperature and low moisture content which are unsuitable for the activity of soil micro-organisms. This causes a reduction in carbon and nitrogen contents in soil during the summer at each depth of all the three plots but this decrease is minimized as the depth increases. The maximum decline in the amount of carbon and nitrogen was found in plot I due to the second burning in May. However, the I and the II plots respectively had 7.8% and 5.6% more of nitrogen and 40.6% and 31.2% less of carbon at the top layer of soil as compared to those of the control plot during June. The relatively rapid disappearance of carbon in the control as well as in the burnt plots resulted in the narrowing of the C/N ratio at each depth in all the three plots. The C/N ratio was found to be the lowest in plot I as a result of comparatively high amount of nitrogen and less amount of carbon in soil. The highest ratio was obtained in plot III.

During the rainy season the concentration of carbon and nitrogen increased at each depth in each plot since high moisture with suitable temperature enhances the microbial activity that results in rapid decomposition of plant material as well as greater nitrogen-fixation in soil. The nitrogen content in soil was maximum during September and carbon concentration was highest during August at each depth in all the three plots. Moreover, the increase in carbon content was comparatively very high in relation to nitrogen content which explains the increase in

C/N ratio of soil during the rainy season. It is also evident that the ratio varies in different months of rainy season. Thus indicating that the soil organic matter was at different stages of humification. The results are in general conformity with Jenny's conclusions (Jenny, 1930). Similarly, Raychaudhuri & Rosha (1961) working on crop fields in semi-humid and humid regions in India found that with increase in rainfall, both carbon and nitrogen contents increase in soil and the carbon-nitrogen ratio shows wide variations with different rainfall ranges. The value of carbon-nitrogen ratio was maximum in the first plot and least in the third plot. Contrary to it the surface soil showed the lowest C/N ratio in the first plot, intermediate in the second plot and most in the third plot. The decreasing trend in the ratio was noted during winter season at each depth in all the three plots since the unfavourable condition for microbial activity during winters reduced the concentration of carbon and nitrogen in soil. The results indicate that the top soil showed the lowest C/N ratio in the twice burnt plot, and most in the unburnt control plot throughout the study period. Thus, the C/N ratio may serve as an index of the frequency of burning

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