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Original Research Article

Effect of Forest Fire on Nitrogen, Potassium and Microbial Biomass Carbon in Different Land Uses under Chir Pine (*Pinus roxburghii*) Forests of North Western Himalayas

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Keywords

Nutrient management, Microbial biomass, Nitrogen economy, Forest fire, PVC core sampling

ABSTRACT

The objective of the study was to evaluate the effect of forest fire on nitrogen, potassium and microbial biomass carbon. Four different land uses viz. forest land, grass land, agricultural land and non fire site as control were prevalent and selected for study. Soil sampling on was done alternate monthly basis in replicates with standard PVC core sampling technique. Results of the study revealed that soil available nitrogen and potassium content was increased after onset of fire. Highest soil available N and K content (437.58 and 453.61 kg/ha) was recorded in agricultural based land followed by control (323.98 and 348.65 kg/ha). Maximum soil microbial biomass was associated with forest land (175 µg g^{-1}) followed by 153 µg g^{-1} under agricultural land. Overall agricultural based ecosystems maintained higher nutrient concentrations and microbial biomass after fire as compared to rest. Fire resulted in increased nutrient availability and higher microbial biomass as compared to non fire site.

Introduction

Himalayan forests are rich in faunal and floral diversity and therefore home to thousands species of animals and plants. But in the dry months, rains are scanty and thus forests become heavily littered with dry leaves and twigs which act as fuels for forest fire. Forest fire is disrupting the forest wealth, ecology and biodiversity of these regions since centauries. The Himalayan forests are the most vulnerable and have been burning every year with huge loss of vegetation cover .Large scale expansion of pine forests under forestry department of the state increased this rate of burning as these trees contain bio fuels and oils. Chir pine forest thrives in rainfall of 600 mm with mean annual temperature of 16 ^{0}C (Climent *et al.*, 2004). They best grow between 1200 m to 1800 m amsl which make them best to grow in the mountainous region. The inclusion fire on forest landscape is majorly dependent on the duration of fire (Shakesby and Doerr, 2006). Therefore, long duration fire could lead to increased erosion rate, soil hydrophobicity which ultimately reduces the organic matter and migration of wildlife. But high severity fires can be lethal to many trees within the entire stand and can effectively influence the whole forest structure (Sherriff and Veblen, 2006). However, with the passage of time the things returns to normal as the vegetation cover and faunal activities again observed similar pre fire conditions. Besides the negative effects, the forest fires plays an important role in mineralization of different minerals essential for plant growth e.g. transformation of organic nitrogen to inorganic forms such as nitrates which are plant available forms. Fires take up nitrogen from the surface soil and plants and reduce of N pool in a burned forest (Hyodo *et al*., 2013). Forests fire reduce the abundance and population of soil microbes to a large extent instantly but with duration the activities again appears to be normal conditions. Fire result in reduction of microbial abundance by an average of 33.2 per cent and fungal abundance by an average of 47.6 per cent (Dooley and Treseder, 2012). Fire also alters soil physical and chemical properties including soil structure deterioration, reduction in organic matter, porosity and increased pH (Certini, 2005).

Forest fires produce smoke and many noxious gases such as carbon monoxide, methane, hydrocarbons, nitric oxide and nitrous oxide which lead to serious problems for environment. Other losses due to forest fire i.e. loss of soil fertility, soil erosion, loss of employment, drying up of water resources, loss of bio-diversity and changes in microclimate of the region in the form of soil moisture balance and increased evaporation cause a serious problem and which need to be solved. Although fire lowers the nutrient pool in the soil but on the other hand it increases the nutrient availability. Therefore, soil fertility can be improved with inclusion of low intensity fires as fire acts as major mineralizing agent and transform nutrients bound to dead plant tissues (Schoch and Binkley, 1986). Forest fires influences nutrient pools directly and indirectly as it quantifies the amounts of nutrients to be volatilized. Different soil nutrient tend to behave differently to fire as concentration of potassium, calcium, and magnesium ions in the soil can increase or be unaffected by fires whereas nitrogen and sulphur concentration often decreases (Hough, 1981) e.g. N begins volatilizing out of organic matter at only 200º C, whereas Ca must be heated to 1240º C for vaporization to occur (Neary *et al*., 1999). Very few research works has been done on the effect of fire on the nitrogen, potassium and microbial biomass carbon in chir pine forests of North Western Himalayas.

Materials and Methods

The present study was conducted in Solan region, falls in climatic zone of sub-temperate in Himachal Pradesh (Zone-2). Mean annual temperature of 17.4^{o}C with annual rainfall of 1100 mm was recorded throughout the study period. The region has mountainous topographical conditions and winter rains are meager and majorly received during the months of January to March. Four different land uses viz. forest area, grassland area, agricultural land area and non fire site taken as control are prevalent in the region and thus selected for the study. For the sampling sites, plots of 200 m x 500 m were selected for each land use. As control non fire site was selected separating the fire areas with a distance of 2 kms. Regarding soil sampling, standard PVC core sampling technique was practiced in which cores with 5 cm diameter perforated with 5 holes were driven into the surface soil to a depth of 10 cm followed by capping on top. Three parallel lines were arranged separating each other by 15 cm were taken as replication to maintain heterogeneity in sampling. Different physio-chemical parameters were determined by soil sampling done on alternate month's basis from all the respective sites. Initial samples were drawn near the core and further samples were collected from the core with minimal disturbance.

Results and Discussions

Soil available nitrogen and potassium

The study revealed that forest fire improved the soil nitrogen content soil in all the selected land uses. Maximum nitrogen contents of 191.52, 193.54, 437.58 and 323.98 kg/ha was associated with March month in all the land uses (Table 1). The duration of fire showed promising results on nitrogen levels in soil. Conversely with the initiation fire the available nitrogen was found to be lowered as compared to pre fire levels. Similar findings were reported by (Hyodo *et al*., 2013). Soil available potassium was found to be increased with duration of fire and therefore maximum concentration was recorded in the month of March in agricultural and control site. In forest and grass land the soil available potassium concentrations were found to be decreased with duration of fire which might be due to lower soil temperature, low soil moisture and zero tillage which might have reduced the K concentration. Among the different land uses, maximum concentration of potassium was recorded in agricultural based land use i.e.453.61 kg/ha which could be due to application of inorganic fertilizers and manures to crops which might have increased soil K. It is very clear from the Fig. 1 and 2 that the N and K concentration has been improved with the passage of time and therefore showed promising results with positive relationship between fire and nutrients transformation.

Soil microbial biomass (μg g^{-1})

The results of the study revealed that soil microbial biomass content was found to be reduced initially after fire i.e. biomass content is reduced in September, but with the duration of fire the biomass content was found to further increase with maximum of 175, 145.4, 153 and 147.4 μg g^{-1} in respective land uses (Table 2). Among the different land uses maximum value of microbial biomass was observed in forest land i.e. 175 μg g^{-1} followed by agricultural land (153 μg g^{-1}) (Fig. 3). Higher microbial biomass might be due to regeneration of new flora after fire and incorporation and decomposition of litter increased the nutrients pool in soil which serve as energy source to the microbial population. Fire being a mineralization agent might have increased the available nutrient content which can easily taken up by the soil microbes. Similar findings have been earlier reported by (Schoch and Binkley, 1986). Increased microbial biomass in agricultural based land use could be explained by the fact that addition of previous crop straw might have increased the microbial functional diversity.

Table.1 Soil initial physio-chemical properties under selected land use patterns

Initial physical and chemical properties								
Land use	**Particle density (g cm^{-3})**	**Bulk density (g cm^{-3})**	**Porosity (%)**	**pH (1:2)**	**Electrical conductivity (ds m^{-1})**	**Organic carbon (%)**	**Available N (kg ha^{-1})**	**Available K (kg ha^{-1})**
Forest land	2.32	1.33	42.70	5.93	0.22	1.18	173.18	272.68
Grass land	2.33	1.34	42.48	6.05	0.24	1.31	179.54	319.54
Agricultural land	2.35	1.36	42.12	6.44	0.27	1.22	390.28	431.88
Control (Non fire site)	2.32	1.33	42.67	6.57	0.25	1.17	291.29	339.52

Table.2 Effect of forest fire on available nitrogen, potassium and microbial biomass carbon content of the soil

Soil Parameters	Months	Forest land	Grass land	Agricultural land	Non fire site (control)
Nitrogen (kg/ha)	**July**	175.12	182.86	388.12	296.24
	September	183.64	186.9	413.24	304.48
	November	186.56	189.54	419.46	309.25
	January	188.44	189.65	421.84	311.68
	March	191.52	193.54	437.58	323.98
Potassium (kg/ha)	**July**	280.896	331.45	441.57	347.9
	September	281.68	327.89	445.64	349.24
	November	272.56	334.63	452.81	347.42
	January	267.91	333.56	446.12	352.98
	March	275.8	330.84	453.61	348.65
Microbial biomass carbon(μg g^{-1})	**July**	163	137.0	148.7	142
	September	158.75	131.0	145.2	138.2
	November	166.3	139.3	149.2	143
	January	173.3	141.0	151.4	146
	March	175	145.4	153	147.4

Fig.1 Monthly variations in the available soil N content (kg/ha) after fire incidence

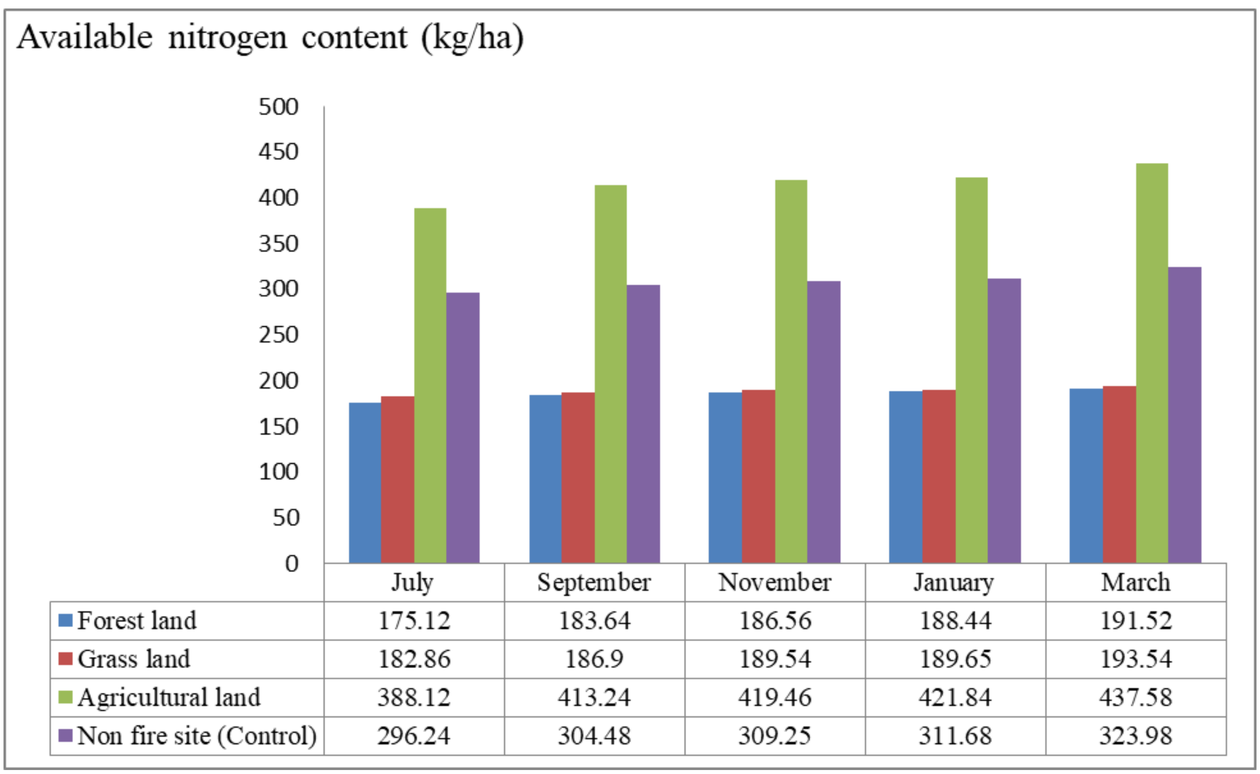
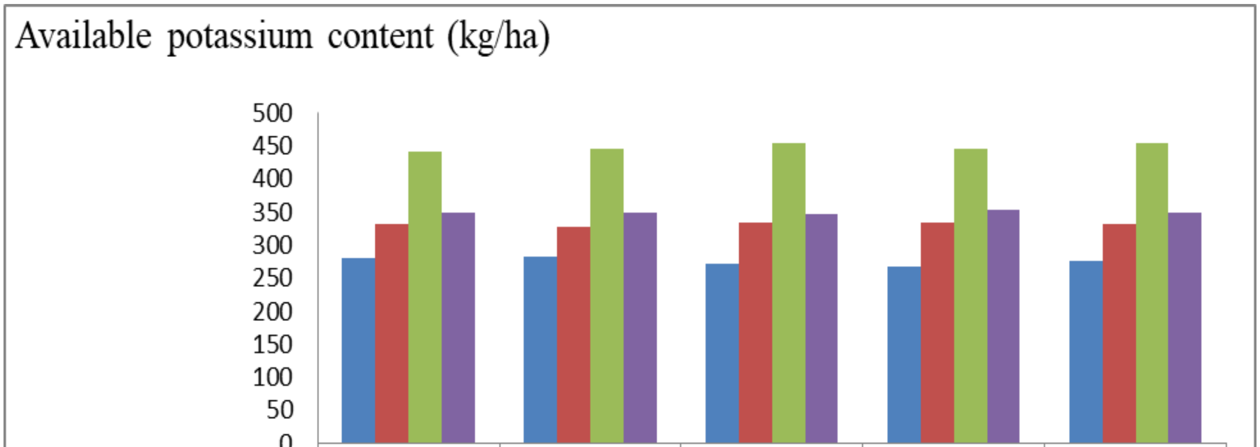
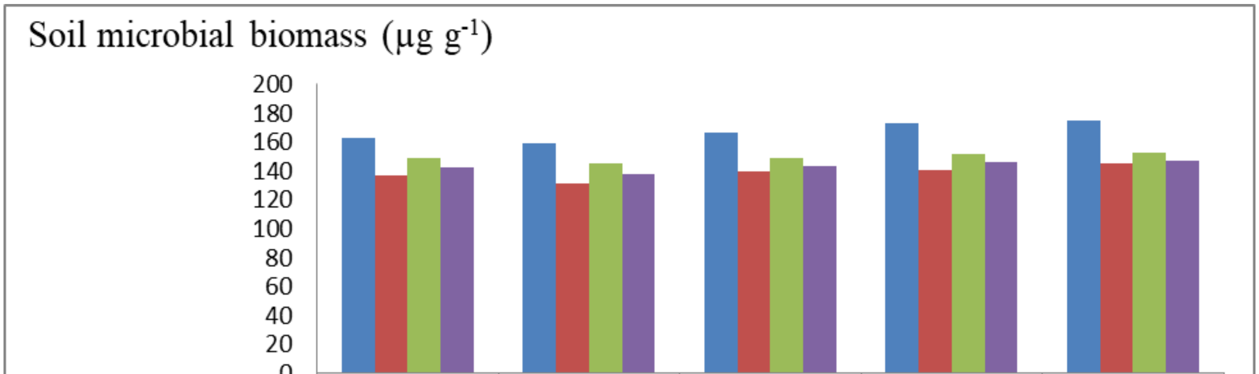


Fig.2 Monthly variations in the available soil K content (kg/ha) after fire incidence



	July	September	November	January	March
Forest land	280.896	281.68	272.56	267.91	275.8
Grass land	331.45	327.89	334.63	333.56	330.84
Agriultural land	441.57	445.64	452.81	446.12	453.61
Non fire site(Control)	347.9	349.24	347.42	352.98	348.65

Fig.3 Monthly variations in the soil microbial biomass (µg g^{-1}) after fire incidence



	July	September	November	January	March
Forest land	163	158.75	166.3	173.3	175
Grass land	137	131	139.3	141	145.4
Agricultural land	148.7	145.2	149.2	151.4	153
Non fire site (Control)	142	138.2	143	146	147.4

Immediate reduction in microbial biomass could be due to increased in soil temperature which might have decreased the microbial activities and reduced liable C content in the soil.

Implication

Findings of the study conclude that the forest fire has positive relationship with the nutrient transformation. Soil available nitrogen and potassium content were increased with the passage of time after incidence which could be a good alternate for nutrient recharge in the soil pool. Moreover, increased microbial biomass after fire incidence point towards higher microbial activities and thus higher carbon sequestration in the soil.

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