Soil organic matter, soil pH and soil nutrient dynamics in forest stands after fire

Yrd.Doç.Dr. Lokman Altun[1]

Prof. Dr. Ertuğrul Bilgili[1]

Araş.Gör. Dr. Bülent Sağlam[2]

Araş.Gör. Ömer Küçük[3]

Arş.Gör. Murat Yılmaz[1]

Yrd. Doç. Dr. Aydın Tüfekçioğlu[2*]

[1] K.T.Ü. Orman Fakültesi, Orman Müh. Bölümü, 61040 Trabzon

[2] K.Ü. Artvin Orman Fakültesi, Orman Müh. Bölümü, 08000 Artvin

[3] Gazi Ünv., Kastamonu Orm. Fak., Orm. Müh. Böl., Kastamonu

*Corresponding Author,

Address: K.Ü. Orman Fakültesi 08000 Artvin

Tel: 466 2125074, Email: atufekci27@yahoo.com

Abstract

Fires burn, spread and release energy. The process of burning not only helps increase the decomposition of organic matters but also causes the plant nutrients bound to vegetation and organic dead material to get into soil and inflicts changes on the physical and chemical properties of soil. Changes taken place in soils and their status over time are extremely important for the success of the vegetation that will establish on the site after fire. This study presents the results of a study conducted to monitor the changes in plant nutrients and soil's chemical properties. In the study, soil organic matter, soil reaction (pH), salinity and soil nutrients were measured. Soil reaction, N and K slightly increased after fire and decreased gradually thereafter. Other nutrients gradually decreased after fire throughout the study period. As a result, it can be said that the effect of fires on soils in areas having little or no dead surface fuels are limited, yet important.

Key words: Forest fires, Maquis, Plant nutrients, soil reaction

Introduction

Forest fires have important effects on forest ecosystems. Fire causes important changes in physical, biological and chemical properties of soil. These changes influence establishment success of after-fire vegetation of the burned area.

Changes in the chemical properties of soils after fire are more important compared to changes in the biological and physical properties. Fire, directly influence soil chemistry by helping defragmentation of clay minerals and indirectly by converting organic matters into inorganic forms. Fire provides soil ash which is rich in magnesium, potassium and calcium. This increases soil pH in acidic and neutral soils, causes no change in pH in basic soils (Chandler et al. 1991). The magnitude of pH change controlled by factors such as amount of substrate, amount of ash, chemical content of ash, soil organic matter content, annual precipitation (Grier 1975, Lutz 1956, Wells 1971).

There are lots of studies done on nutrient dynamics after fire (Cooper 1971, Stone 1971, Wells 1971, Neyişci 1989). Fire causes depletion of organic material in the soil surface. But nutrients in the ash stay in the surface until they move down into soil profile by the rain. This causes depletion of P, K, Ca and Mg in the soil surface and increase of these nutrients in the deeper horizons (Wells 1971).

In Turkey, major effort has been given to prevent fire instead of understanding ecology and dynamics of fire. Therefore, there are few studies dealing with influence of fire on soil nutrient dynamics.

In this study, influence of forest fires on some chemical soil properties and their dynamics have been investigated in Soke Forest District, in Aydin, Turkey.

Materials and Method

The study site located at Söke Forest District, in Aydın, Turkey. Vegetation type in the study area is maquis. The elevation of site is 80 m. from sea level and mean slope is 5%. Mean annual rainfall is 657.7 mm. Parent material of the study area is limestone and soil type is ranker. Study area has mediterranean climate type with warm winters and hot summers.

First soil samples were taken following fire from control (3 sites) and burned sites(3 sites). After that, samples were taken monthly in first year and in two to three months in second year. Samples taken from surface 0-20 cm due to difficulty to obtain soil because of shallow parent material.

Analyses were conducted to determine some chemical and physical properties of soil samples. Samples were air-dried, ground and sieved through a 2 mm-mesh-sized sieve (Gülçür, 1974). Field capacity, wilting point and available water content of samples were determined following the procedure described by Gülçür (1974). Organic matter content was determined by wet digestion (modified Walkley-Black Procedure) method (Kalra and Maynard, 1991; Gülçür, 1974). Soil pH was determined by a combination glass-electrode in H_2O (soil-solution ratio 1:2.5). Cation exchange capacity (CEC) was determined by saturating soil samples with NH_4^+ by leaching buffered NH_4OAc solution. Phosphorus determined according to Bray1(Dilute acid-fluoride) procedure (Kalra and Maynard, 1991). Exchangeable cations (Na^+ Ca^{++}. Mg^{++}, K^+) were extracted from the neutral ammonium acetate solution and measured by atomic absorption spectrophotometry (Kacar, 1996). Salinity was determined by following the procedure described by the Gülçür (1974).

Results and Discussion

Soil pH increased slightly after fire but it returned the same level as it was before fire at the end of one year and the following year. This could be due to two reasons: first, soil pH was quite high before fire, second, the fire was not strong enough to cause dramatic changes in soil pH. Also, the amount of substrate wasn't much enough to cause significant changes in the concentrations of basic cations such as Ca, Mg, Na and K in the soil. Similar results have been observed by Trabaud (1980). He found no significant difference in soil pH after fire in the mediterranean areas.

Electrical conductivity decreased slowly in soil after fire. This could be result of Na leaching from soil during time.

Soil organic matter content showed a slow decrease with time. Decrease in aboveground input of organic matter and increase in the activity of microorganisms after fire could be reason for this slow decrease. Tufekcioglu et al. (1999) reported an increase in soil respiration after fire in cool-season grasslands of Iowa, USA.

Nitrogen content of soils increased for seven months after fire. This could be due to increase in nitrogen mineralization (nitrification) and nitrogen fixation by microorganisms. After two year, nitrogen contents of soils returned to previous level.

Phosphorus content of soils in burned area decreased slowly with time. This was in contrast with findings of Wagle and Kitchen (1972). They observed an increase in the amount of phosphorus after fire in the soil. However, Lloyd (1971) reported that some of the phosphorus bound to ash could be loss by wind erosion or surface runoff.

There was no significant changes in the calcium content of soils after fire. It was expected to see same trend in Mg dynamics of soils. But Mg contents of soils decreased slowly until the end of first year in burned areas. It reached pre-fire level at the end of second year.

Potassium content of soils increased after fire in burned areas and started to decrease after two months. Similar results have been observed by Christensen and Muller (1975). Sodium content of soils were very low in the first six months after fire. After that it raised into values that were very high compared to previous values. We didn't have any clear reason for this change in this study.

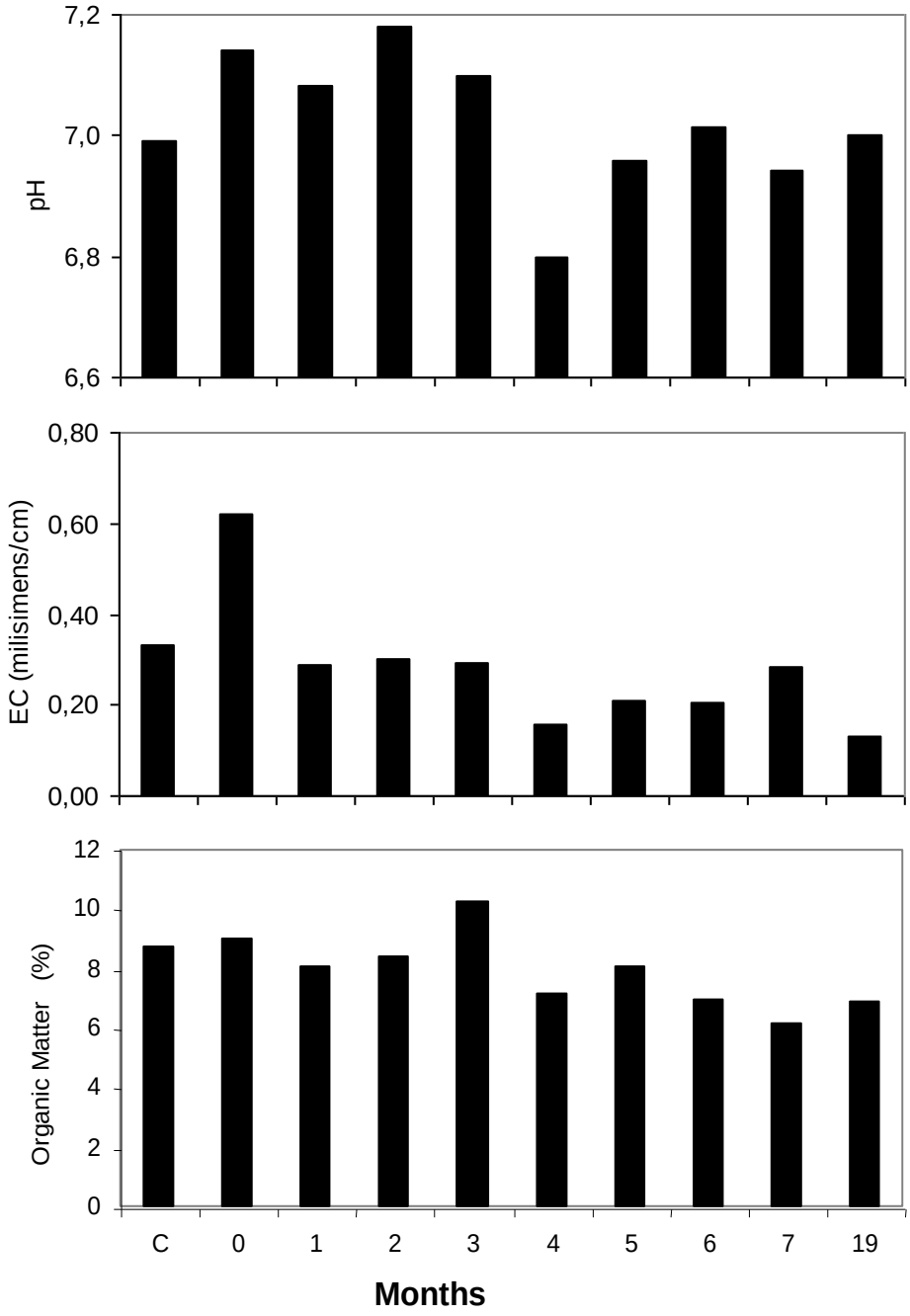

Fig. 1. pH (a), electrical conductivity (b) and organic matter dynamics in soils after fire (C: control)

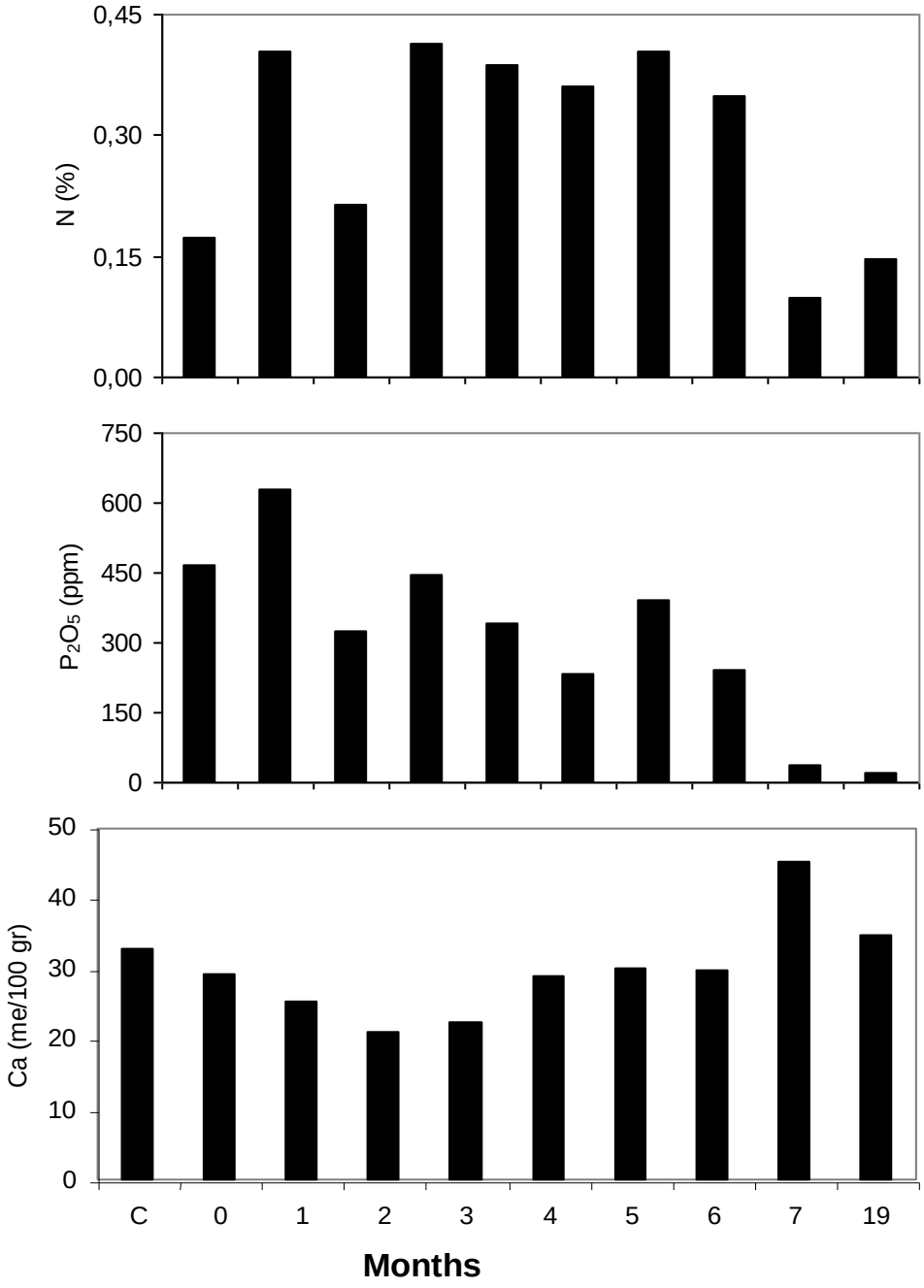

Fig. 2. Nitrogen (N) (a), phosphorus (P_2O_5) (b) and calcium (Ca) (c) dynamics in soils after fire (C: control)

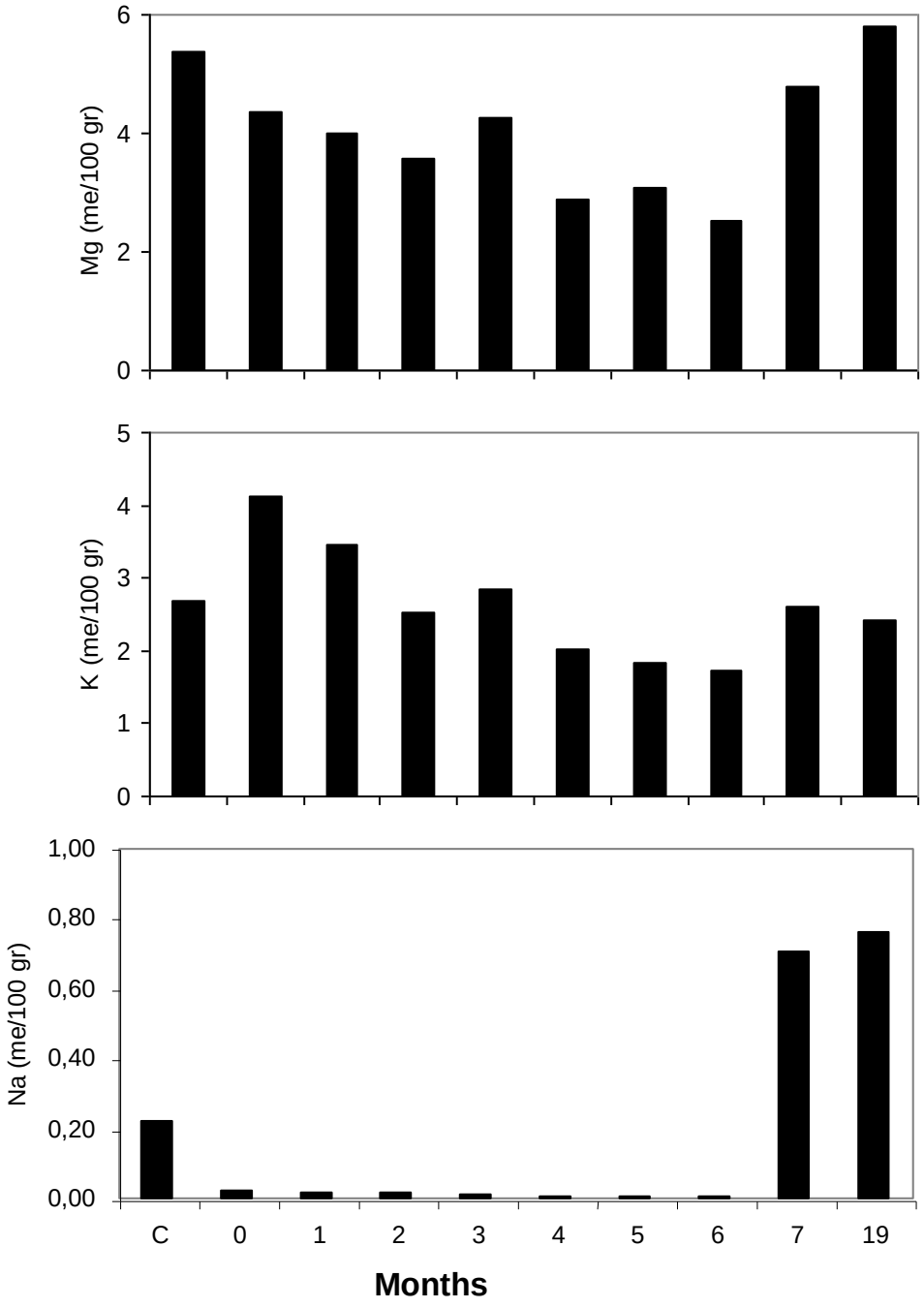

Fig. 3. Magnesium (a), potassium (b) and sodium (c) dynamics in soils after fire (C: control)

Conclusions

Our results indicated that some chemical properties of soils changed by the fire. After a medium strength fire, concentrations of some nutrients (N and K) in soils were increased by some processes triggered by the fire. On the other hand, fire caused a slight increase in soil pH while it caused a slight decrease in soil organic matter content. P and Mg concentrations in soils were decreased after fire.

The study done in a small area, for a specific vegetation type. Therefore, similar studies need to be done in different areas under different vegetation types and ecological conditions before generalization of the findings of this study.

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