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Effects of Iron Wood (*Parrotia persica* C.A. Meyer) Leaf Litter on Forest Soil Nutrients Content

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Abstract: *Parrotia persica* or Iron wood is a unique broad leaves species in Hyrcanian forest of IR-Iran. The produced leaf litter by this species is an intrinsic component of the ecological integrity of a forested ecosystem. In present study the soil of leaf litter beneath and control plots were sampled at the depth of 0-10 cm. Samples were analyzed for macro and micro nutrients content. The fresh leaves of *Parrotia persica* were also collected and nutrients content were determined. Results indicated that the leaf litter decreased the soil electrical conductivity and pH ($P<0.05$) and increased the soil T.N.V, organic matter, organic carbon and nitrogen ($P<0.05$). Leaf litter hadn't significant effect on soil phosphorous, potassium and copper content ($P>0.05$). Magnesium and iron were more in *Parrotia persica* summer leaves in proportion to other elements, while leaf litter increased the magnesium and decreased the iron of soil. In addition, the maximum changes in soil nutrients occurred for organic matter, organic carbon and nitrogen.

Key words: *Parrotia persica* · Leaf litter · Soil · Nutrient · Hyrcanian forests

INTRODUCTION

Leaf litter is an intrinsic component of the ecological integrity of a forested ecosystem. This is evident through the many processes within a forest ecosystem that are influenced by the quality and quantity of leaf litter [1]. Specifically, studies on leaf litter evaluate the leaf litter quantity and nutrients content to determine energy fluxes and productivity [2]. This is largely because leaf litter and its subsequent decomposition, strongly influences primary production and regulates energy flow and nutrient cycling in forest ecosystems [3]. Thus, leaf litter is a major participant in the transfer of energy and nutrients in a forest ecosystem [4, 5].

Retranslocation of nutrients from senescing tissues, often referred to as resorption [6], is an important aspect of the nutrients economy of perennial plants and a major influence on ecosystem nutrient dynamics [7, 8]. Most perennials resorb 40-65 % of nitrogen and phosphorus from leaves before abscission [9], permitting these nutrients to be recycled internally and used in the construction of new tissues [10, 11]. Although the magnitude of nutrient fluxes may be controlled by local factors such as soil fertility, temporal patterns are likely regulated by a common environmental variable such as precipitation or temperature [12-14].

The weight of litter falling annually increases with stand age. This increase is due mainly to greater amounts of twigs, bark and fruit falling in older stands [15]. Leaf fait is relatively independent of stand age once the canopy of regenerating stands closes and the understorey has developed. Content of N, P, K, S and Mn in leaf litter differ significantly between sites and the differences appear to be related to stand age. The highest levels of these elements are found in leaf litter from the youngest stand and the contents were decreased with increasing stand age. Understorey leaf material is particularly important in the cycling of N, S and the micro-nutrients Cu and Zn [16, 17].

Rates of key soil processes involved in recycling of nutrients in forests are governed by temperature and moisture conditions and by chemical and physical nature of the litter [18, 19]. The forest canopy influences all of these factors and thus has a large influence on nutrients cycling. Although effects of tree species on soil nutrient availability were thought to be brought about largely through differences in the decomposition rate of their foliar litter, recent studies indicate that the effect of tree

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species can be better predicted from the mass and nutrient content of litter produced, hence total nutrient return, than from litter decay rate [20, 21]. The greatest canopy complexity in mixed species forests creates similar heterogeneity in nutritional characteristics of the forest floor [22, 23].

The objective of this study research was (i) to determine the impact of *Parrotia persica* C.A. Meyer., leaf litter cover on forest soil macro and micro nutrient content and (ii) to assess the leaves macro and micro nutrients content in summer season.

MATERIALS AND METHODS

***Parrotia persica* C.A. Meyer (Iron Wood):** *Parrotia persica* (DC) C.A. Meyer (Persian Ironwood) is a deciduous tree of the family Hamamelidaceae. It is native to northern Iran and endemic to the Alborz Mountains. *Parrotia persica* is usually a low-branched and multistemmed small specimen tree with beautiful, exfoliating bark, flowers having showy red stamens and leaves that turn from dark green in summer to an autumn color consisting of a mix of brilliant yellow, orange and red. Persian Parrotia provides significant autumn and winter interest [24].

Site Description: Hyrcanian forests with an area of about 1.9 million hectare are located in north of Iran, in southern coast of Caspian Sea. It is exclusive site for some valuable and unique species like *Gleditsia caspica* Desf., *Parrotia persica* C.A. Meyer. and *Pterocarya fraxinifolia* (Lam.) Spach [25, 26]. The experiment was conducted in 2008 growing seasons in Khalkheil forests (53° 16' 10" to 53° 22' 55" N latitude and 36° 16' 45" to 36° 21' 35" E longitude) located in north of the IR-Iran. This area experiences a cold mid moist climate; with an average annual precipitation of around 700 mm. The chosen site is located on a south-facing slope, 400-600 m above sea level. Average daily temperature is 14°C. The soils are deep, moderately well drained. They have the textures of loam and loam silt. The Khalkheil forests bedrock is lime marl, sand lime and lime conglomerate. This area has been dominated by the natural forests containing native tree species such as *Parrotia persica, Carpinus betulus L., Zelkova carpinifolia, Gleditschia caspica Desp* and etc. The surrounding area is dominated by agricultural fields and rural buildings. Figure 1 show the local cycles of nutrients in hyrcanian broad leaved forests of Iran.

Fig. 1: Geographic distribution of *Parrotia persica* (green strip on the map) and local cycles of nutrients between leaves litter, decomposers and soil

Soil Macro and Micro-Nutrients Analysis: Soil was collected from 0-10 cm depth under the *Parrotia persica* decomposed leaf litter cover. Soil texture was determined by the Bouyoucos hydrometer method. PH was measured using an Orion Ionalyzer Model 901 pH meter in a 1:2.5, soil: water solution. EC (electrical conductivity) was determined using an Orion Ionalyzer Model 901 EC meter in a 1:2.5, soil: water solution. Soil organic carbon was determined using the Walkley-Black technique. The total nitrogen was measured using a semi Micro-Kjeldhal technique. The available P was determined with spectrophotometer by using Olsen method. The available K was determined by ammonium acetate extraction at pH 9 and Mg, Zn, Cu, Mn and Fe were determined with Atomic absorption spectrophotometer.

Leaf Macro and Micro-nutrients Analysis: *Parrotia persica* leaves nutrients content were measured using randomly selected blocks in the field. In August 2008, 60 fresh leaves from current year shoots were collected and immediately frozen on dry ice until laboratory analysis. In laboratory the *Parrotia persica* leaves were packed piecemeal in clean envelopes and were further dried for 48 h in an oven maintained at 60 °C. They were then ground to fine powder using pestle and mortar. For the determination of total N, 150 mg of the leaf powder was digested in concentrated H_2SO_4 following Automated Kjeldahl method. The digested product was diluted to 100 ml and the resulting ammonium was then measured using FIA (Flow Injection Analysis) method. Ca, Fe, K, Mg and P were determined by boiling 2.5 g of the powdered leaf material in concentrated HNO_3. Excess acid was decanted and the boiled sample was diluted to 25 ml. The elements were then determined using ICP OES (Inductivity Coupled Plasma Optical Emission Spectroscopy) method.

Statistical Analysis: The SAS package was used to perform all statistical analyses of macro and micronutrients. Significant differences among treatment means were tested using analysis of variance (one-way ANOVA). Wherever treatment effects were significant the Duncan's Multiple Range Test was carried out to compare the means. The values found for the some leaf nutrient and soil nutrient under leaf litter were compared statistically at 0.05 significant levels by using t-test statistical analysis.

RESULTS AND DISCUSSION

The availability of nutrients in forest ecosystems depends on efficient recycling of nutrients within the ecosystem [5, 9]. Through this cycle, nutrients are returned to the soil in litter following the death of plant tissues, released from the litter through decomposition and mineralization, recycled through soil organisms and taken up by vegetation [15]. Rates of decomposition and nutrient mineralization are governed by temperature and moisture conditions and by the chemical and physical nature of the litter [5, 27].

Results of this research showed that the *Parrotia persica* leaf litter decreased the soil EC and pH ($P<0.05$) and increased the soil T.N.V, O.M, O.C and N ($p<0.05$). The mean phosphorous content of control plots (28.4 mg kg^{-1}) was less than the sampled soil from *Parrotia persica* leaf litter beneath (32.7 mg kg^{-1}). The K content of soil in leaf litter beneath was decreased in comparison to the control. But these differences weren't significant ($P>0.05$) (Table 1).

Freshly Iron wood summer leaves had Mg content of 1700 mg kg^{-1}. This value is significantly higher than the soil of leaf litter beneath and control plots ($P<0.05$). Totally, Mg and Fe elements were more in *Parrotia persica* summer leaves in relation to other elements, but leaf litter causes that the soil Mg content increased and Fe decreased. No significant difference ($P>0.05$) was observed in Cu content between the soil under leaf litter and control (Table 2).

Leaf litter hadn't significant effect on amount of forest soil sand and silt particles ($P>0.05$), while it significantly ($P<0.05$) decreased the clay percentage (Table 3). It seems that the micro-organisms activity and production of gooey matters are main factors in the reduction of clay percentage [3]. The micro-fauna such as complexes of bacteria, fungi and soil organisms, which can move freely through the litterbag net, have been shown to cause an increase in weight loss of leaf litter [28].

Maximum changes in soil nutrients occurred for organic matter, organic carbon and nitrogen (Fig. 2). The mean phosphorus ($p=0.01$), nitrogen ($P=0.001$) and potassium ($P=0.001$) content were significantly different between soil of leaf litter beneath and *Parrotia persica* summer leaves (Fig. 3). Nutrients release from decomposing leaf litter is important for sustaining ecosystem production [12]. Changes in litter quality have the potential to alter nutrients dynamics by changing substrate availability for microbial metabolism [23]. Also,

Table 1: Comparison of soil nutrients content under the *Parrotia persica* leaf litter and control plots

Sampling site	Depth (cm)	EC	pH	T.N.V (%)	O.M (%)	O.C (%)	N (%)	P (mg kg^{-1})	K (mg kg^{-1})
Litter beneath	0-10	0.62^b	5.67^b	4.7^a	24.42^a	14.20^a	1.18^a	32.7^a	415^a
Control	0-10	0.95^a	5.93^a	3.3^b	11.35^b	6.60^b	0.55^b	28.4^a	430^a

In a same column, values with same superscript are not significantly different at 5% level (Duncan's test)

Table 2: Comparison of nutrients content between soil and *Parrotia persica* summer leaves

Sampling site	Mg (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})
Leaf litter beneath	700^b	150.0^b	40.0^{ab}	6.8^{ab}	1.6^b
Control	425^c	200.0^a	32.5^b	3.9^b	1.1^b
Summer leaves	1700^a	210.5^a	54.7^a	9.5^a	10.5^a

In a same column, values with same superscript are not significantly different at 5% level (Duncan's test)

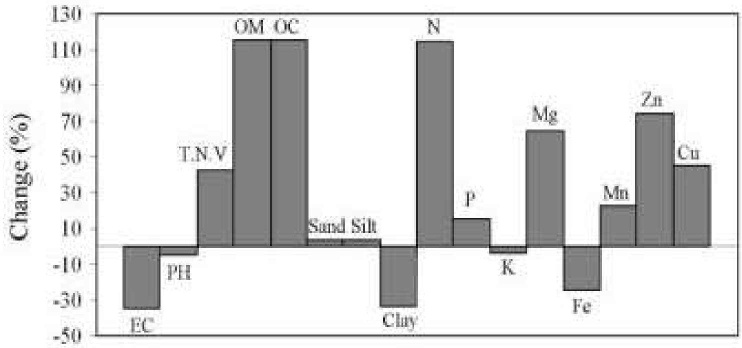

Fig. 2: Percent change of characteristics in control and soil of leaf litter beneath

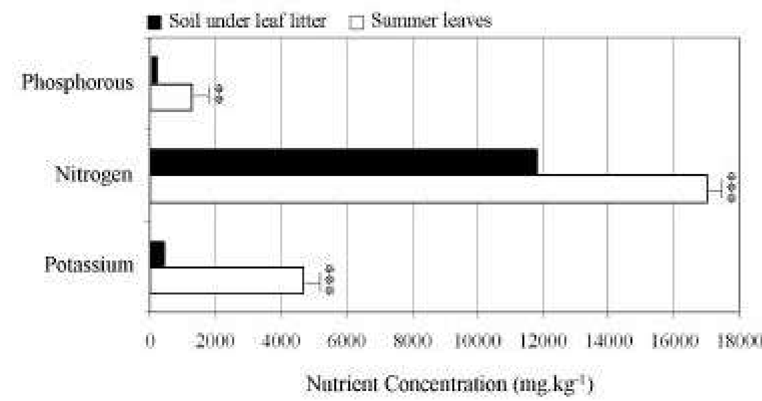

Fig. 3: Comparison of P, N and K content between soil under leaf litter and Parrotia summer leaves

Table 3: Comparison of soil properties under *Parrotia persica* leaf litter and control plots

Sampling site	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture
Leaf litter beneath	0-10	63[a]	29[a]	8[b]	S.L
Control	0-10	61[a]	27[a]	12[a]	S.L

In a same column, values with same superscript are not significantly different at 5% level based on Duncan's test

rising atmospheric CO_2 and troposphere O_3 could strongly influence on nutrients release from leaf litter [21].

Decomposition of leaf litter, by which organic matter and nutrients are returned to the forest soils, is a primary mechanism and has received considerable attention for sustainable soil fertility [27, 29]. The rate of litter decomposition has been associated with the carbon and nitrogen content [30, 31].

CONCLUSIONS

The study of energy and nutrients distribution and the dynamics of chemical elements within an ecosystem are referred to as biogeochemistry. Nutrients cycling in a forested ecosystem largely determines the system's characteristics. Decades of research found the abundance, distribution and productivity of organisms within an ecosystem proportional to the availability and transfer of energy. In general, a forest is an open ecosystem where nutrients and energy are influenced by inputs gained from various interacting sources, outputs lost to different sinks and an array of internal cycling. Nutrients cycling within a forest ecosystem is displayed in Fig. 1. There are three basic components of biogeochemistry: geochemical, biogeochemical and biochemical.

In conclusion, results from our study indicate that the *Parrotia persica* leaf litter decreased the soil EC and pH and increased the soil T.N.V, O.M, O.C and N. The maximum changes in soil nutrients occurred for organic matter, organic carbon and nitrogen. In fact, decomposition of leaf litter, by which organic matter and nutrients are returned to the forest soils, is a primary mechanism and has received considerable attention for sustainable soil fertility. Mg and Fe elements were more in *Parrotia persica* summer leaves in proportion to other elements. It seems that these elements have a main role in color changes of Parrotia leaves. Of course, more research is need to discovering the reasons of this phenomenon.

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