

# *Effects of Substitution of Degraded Natural forests with Plantations on Soil Carbon Sequestration and Fertility in North of Iran*

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## **Introduction**

Increasing concentration of atmospheric CO<sub>2</sub> is one of the most important reasons for climate changes and global warming. one of the most appropriate solutions offered to solve this problem is its reduction by carbon sequestration in soil by plants.

Concentration of atmospheric CO<sub>2</sub> will increase to the range of 415 to 421 ppm in 21st century. Only with optimistic assumptions and low growth rates, increase of carbon-dioxide-induced temperature will be held below 2°C over the next century. Conservation, flexible energy choices and control options could lessen the potential effects of carbon dioxide otherwise it will cause global warming crisis. Besides the economic and social disadvantages, it will lead natural ecosystems to loss their stability. Thus, effort to reduce greenhouse gas concentrations through suitable management is important and ultimately will lead to sustainable development. Methods such as filtering to reduce the concentration of carbon dioxide in the atmosphere will be high costly. So at the macro levels it will not operational. The world needs to reduce the concentration of CO<sub>2</sub> can be satisfied by less expensive methods such as the carbon sequestration by plants.

Carbon sequestration is a process that CO<sub>2</sub> is taken from the atmosphere and stored as carbohydrates in plant tissues. Then part of the carbon will be stored in litters and soil. Since the carbon sequestration by plants is one of the most important strategies for dealing with global warming crisis, so far many researchers have been studied the effects of substitution of natural forests with plantations on soil carbon sequestration. In Iran, also some researchers studied on effects of plantation with different species on soil carbon sequestration. But until now there were no research on the effects of substitution of degraded natural forests with plantations on soil carbon sequestration in Iran. So this study will investigate the effect of *Acer velutinum*. Boiss and *Alnus subcordata* L. plantations after 18 years on soil carbon sequestration and fertility in a region that previously was a degraded natural forest stand. By using these results we can have effective steps on future planning for reforestation and substitution in these areas.

## **Materials and methods**

### **Study area**

The study area is located in north of Iran in Chamestan region of Mazandaran province. The dominant natural forest stood in this area is *Quercus – Zelkova*, but these forests had been damaged by uncontrolled harvesting. So, in 1991, parts of these natural forests (after clear cutting) were reforestation with *A. velutinum* and *A. subcordata* with 2\*2 m planting distance. Three stands (one degraded natural stand and two plantation stands) with 10 ha area for each were selected. The soil characteristics were the same at the time of plantation.

### **Sampling method**

At each stands ten (5\*5 m) plots with randomly-systematic statistical method selected and in each plot the soils were sampled in three depths: <15, 15-30 and 30-50 cm, after removing the litters.

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To minimize the inaccuracy, one additional combined sampling was implemented: the soil samples of the four corners of each plot were picked and then these samples were mixed together. Thus, in every stand for each depth totally ten samples were collected.

- Laboratory research methods:

Samples were air dried and after breaking the gravels into small pieces and removing the roots, stones and other trashes they were grinded and sieved through 2 mm mesh and prepared for chemical analyses. Then Soil organic carbon and 10 soils factors according to the standard methods were measured.

### Statistical methods

The data obtained has been statistically analyzed using the SPSS software. The normality of data was examined with Kolomogorov - Smirnov test and the homogeneity of variances was investigated by Levene test. Attending to the normality and variance homogeneity of data One-way ANOVA test was applied for total comparison of soil characteristics of these three types and we used the Duncan test for multiple comparisons of means

To determine the most important factors affecting soil organic carbon we used multiple regression by stepwise method and the equations were determined.

### Results

Plantation with *A. velutinum* and *A. subcordata* caused significant changes in soil physical and chemical characteristics compared to the primary degraded natural stand. Results showed that the substitution of degraded natural stand with plantations of *A. velutinum* and *A. subcordata* significantly increased soil fertility. No significant differences were observed between the amount of soil organic carbon and nitrogen in studied stands. But significant increase in concentrations of P, Ca and Mg were observed after plantation with two species. Also plantation of *A. subcordata* significantly decreased the concentration of K compared to the primary degraded natural stand.

Results indicate statistically significant differences between soil chemical and physical characteristics of three depths of soil in each stand.

Results of stepwise multiple regression analysis showed that in study area the most important physical and chemical factors of soil that influenced soil organic carbon were total nitrogen content and bulk density.

There were significant differences between carbon sequestration amount of three depths of soil in degraded natural stand and *A. velutinum* plantation. But in *A. subcordata* plantation these differences were not statistically significant.

Overall, the results of this study, the average of soil carbon sequestration (to depth of 50 cm) in plantation stands of *A. velutinum* and *A. subcordata* were calculated 155.04 and 100.88 (Tc/ha) respectively and it was about 121.43 (Tc/ha) in degraded natural stand of *Quercus – Zelkova*. The maple plantation increased soil carbon sequestration (to depth of 50 cm) about 33.61 (Tc/ha) and also plantation with alder reduced it about 20.55 (Tc/ha) compared to degraded natural stand. But these changes were not statistically significant.

### Discussion

In this study the natural stand had been damaged by uncontrolled harvesting which leads to a low concentration of soil nutrients and low amount of organic carbon because of reduction of litter. Also evidence of soil erosion and leaching of elements were observed in this stand (Higher concentrations of these elements in the third soil depth). Harvesting of the forest biomass potentially had an acidifying effect on soil unless the nutrients contained in the biomass returned to soil. So an acidic soil was observed in this stand.

Studies have shown that the broad-leaf trees increase litters production and nutrient returns so they can restore soil fertility in degraded forests.

Therefore, it can be said increased inputs of organic matter and nutrients to soil through increased litter inputs, increased biological activities, changes in microclimate, increased root activities and also the effects of tree canopies in reducing erosion and leaching of organic carbon and nutrients in soil are the

most important reasons for increasing the organic carbon and nutrients in soil under the plantations in this study. *Archive of SID*

The maximum amount of nutrients and organic carbon was measured in 0-15 cm soil depth and significant reduction was observed in their values with increasing the soil depth. It is because of the gradually start of conversion of litter to the humus in surface layer of soil. Erosion and leaching are the reasons of higher amount of organic carbon, total nitrogen, calcium, magnesium and Ec in third depth than second depth in the natural stand.

The most important soil factors that influenced soil organic carbon were total nitrogen content and bulk density. So managing these relations can play an effective role in enhancing carbon storage in soil.

In results of this study it is seen the difference between species and their different effects on soil carbon sequestration. *A. velutinum* increased the amount of carbon sequestration in soil and *A. subcordata* decreased that. It is because of their different potential to sequester the  $CO_2$  from atmosphere.

These results reveal the importance of tree species planting, especially in degraded forests, and their different effects on soil carbon sequestration and fertility. They also express the need to do more studies in this topic.

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### **Key words**

Climate change, Hyrcanian forests, plantation, soil fertility, soil carbon sequestration