Admixture of *Alnus subcordata* with *Populus euramericana* improved soil nitrogen

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Abstract
Concerns about the decline in soil fertility and long-term productivity of fast-growing plantations have promoted interest in using nitrogen-fixing trees in mixed species plantations. Plantations of monoculture *Populus euramericana* and mixed with *Alnus subcordata* were planted in 1987 in Noor, Iran. After 16 years, the effects of species interactions on soil properties were assessed. The results indicated that soil nitrogen, C: N ratio and organic matter at 0-15 cm and 15-30 cm depth of mixed plantation were higher. It can be conclude that admixture of *Alnus subcordata* with *Populus euramericana* improved soil fertility.

Key Words
Nitrogen fixing trees (NFT), mixed plantation, soil fertility, *Populus euramericana, Alnus subcordata*

Introduction

Poplars (*Populus* L. spp.) are preferred plantation species, because their fast growth is expected to meet the extensive demands of wood for poles, pulp and fuel (Kiadaliri 2003; Ghasemi 2000; Ziabari 1993). Productivity of plantations depends strongly on soil nutrient supply and may be malleable under the influence of management practices and species (Binkley 1997). Almost all the industrial plantations are monocultures, and questions are being raised about the sustainability of their growth and their effects on the site (Khanna 1997). Repeated harvesting of fast-growing trees such as poplar plantations on short rotations may deplete site nutrients. Nitrogen losses are likely to be very important for future growth. It is therefore appropriate to explore new systems of plantation management in which N may be added via fixation (Khanna 1997). Mixed plantation systems seem to be the most appropriate for providing a broader range of options, such as production, protection, biodiversity conservation, and restoration (Montagnini *et al.* 1995; Keenan *et al.* 1995; Guariguata *et al.* 1995; Parrotta and Knowles 1999).

A mixture of species, each with different nutrient requirements and different nutrient cycling properties, may be overall less demanding on site nutrients than monoculture stands (Montagnini 2000). Concerns about the decline in soil fertility and long-term productivity of fast-growing plantations have promoted interest in using nitrogen-fixing trees in mixed species plantations (Rhoades and Binkley 1996). Nitrogen-fixing trees, mainly leguminous species, have been widely extolled for their soil-improving characteristics related to their production of nitrogen-rich, often rapidly decomposing leaf litter (Parrotta 1999). Experiments in some parts of world such as North America have shown enhanced growth of *Populus* spp. when grown as an intercrop with *Alnus* L. spp. (FAO 1992, Coté and Camiré 1987, Hansen and Dawson 1982, Radwan and DeBell 1988). The present study was undertaken to assess the influence of *Alnus subcordata* C.A.Mey and *Populus Euramericana* (Dode) Guinier plantations on soil fertility parameters.

Methods

Site characteristics

The study area is located at the Chamestan experiment station, in Mazandaran province, on the northern parts of Iran (36°29' N, 51°59' E). Experimental plots were located at an altitude of 100 m above sea level and with low slope (0–3%). Annual rainfall averages 803 mm, with wetter months occurring between September and February, and a dry season from April to August monthly rainfall usually averages < 40 mm for 4 months. Average daily temperatures ranges from 11.7 °C in February to 29.5 °C in August. The soils are well-drained, and have a silty loam texture with a pH 7.6–8.1. Previously (approximately 50 years ago) this area was dominated by natural forests containing native tree species such as *Quercus castaneifolia* C.A.Meyer., *Gleditschia caspica* Desp., *Carpinus betulus* L., etc. The surrounding area is dominated by agricultural fields and commercial building.

Experimental Design

Plantations of monoculture *Populus euramericana* and mixed with *Alnus subcordata* (50% *P. Euramericana* + 50% *A. subcordata* (50P:50A)), were established in 1987 in Noor, Iran. Tree spacing within plantations was 2 m × 2 m and two species were systematicly mixed between rows. Containerized seedlings, 50–100 cm in height, were used for planting in April 1996. Seedlings of both species were planted simultaneously in monocultures and mixed plantations. Two plantations are beside each other and each of them is about 2 hectare. The control area was in near unmanaged land.

Soils

Soils were randomly sampled from four points in both plantations and control area. Samples were taken to a depth of 60 cm in both plantations in August using a 7.6 cm diameter core sampler (n = 3 cores/plot). Soil samples were taken at two 15 cm and a 30 cm interval. After air drying, soils were passed through a 2.0 mm (20 mesh) sieve to remove roots prior to chemical analyses. Soil organic matter was determined using the Walkley-Black method. Total N was determined using the Kjeldhal method.

Statistical analyses

One-way analyses of variance (ANOVA) were used to compare soil properties among experimental treatments. The Duncan test was used to separate the means of dependent variables which were significantly affected by treatment.

Results

Organic matter was different between 0–15 cm depth for monoculture and mixed plantations, whereas no significant differences were found in deeper soil layer ($p < .08$, Duncan) (Figure 1,a). Total nitrogen had a significant difference between the treatments in 0–15 cm and 15–30 cm soil layers, whereas no significant difference was found in 30-60 cm depth. Total nitrogen in 0–15 cm depth was significantly higher in the mixed plantation ($p < .05$, Duncan) (Figure1,b). C:N ratio show significant differences between the treatments in 0–15 cm and 15–30 cm depth of soil but not in 30-60 cm depth (Figure1,c).

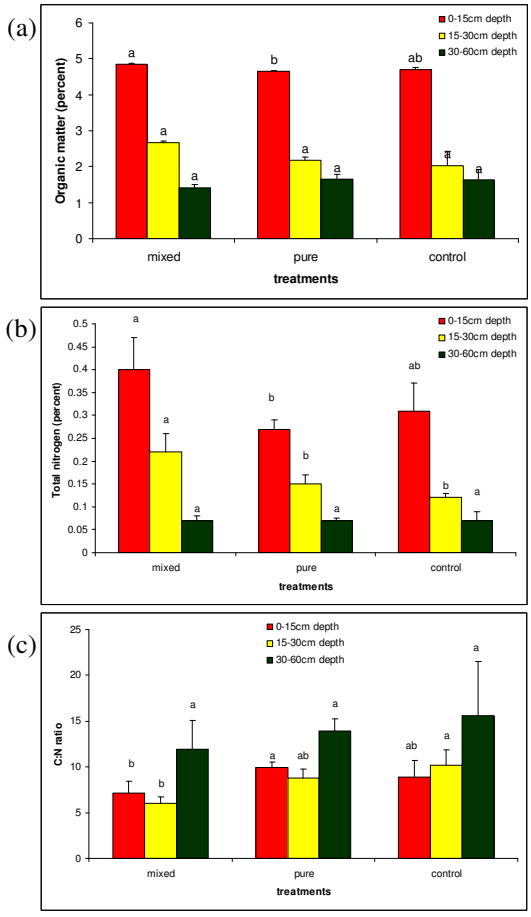

Figure 1. a) organic matter(percent), b) total nitrogen, c) C:N ratio The letters on different column indicate a significant difference. Mean values with the same letter within a tree species do not differ significantly from each other.

Conclusion

Higher Organic matter was observed in the 0-15 cm soil layer for the mixed plantation. This could be due to *Alnus* increasing soil nitrogen in 0-15cm, which is a positive influence of mixed plantations with *Alnus* as an N-fixing tree on nutrition (Fisher and Binkley 1999). The main reason that there was not any significant differences in the deeper soil layer might be the result of higher biological activity in the top soil. Parrotta (1999) came to the same conclusion. Total nitrogen was significantly higher in mixed plantations in comparison with monoculture plantations of *Populus euramericana*. The increase in soil nitrogen of mixed plantations might be the result of nitrogen fxation by nodules of *Alnus* roots and higher litter decomposition rate. Binkley (1997) and Garcia-Montiel and Binkley (1998) found that *Albizia* increased soil nitrogen more than *Eucalyptus*. Parrotta (1999) and to some extent Montagnini (2000) did not observe any significant differences in soil nitrogen between monocultures and mixed plantations. Hansen and Dawson (1982) observed that mixed plantations of *Populus* and *Alnus glutinosa* resulted in increasing soil nitrogen in comparison with their monoculture plantations (FAO 1992). Significant differences were observed in the C:N ratio. The main reason might be N-fixation by *Alnus* in mixed plantations that resulted in increasing nitrogen. Parrotta (1999) obtained the same result for monocultures and mixed plantations of *Eucalyptus* and two NFTs. Finally we can conclude that mixed plantations of these two species improved soil fertility.

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