Catena 90 (2012) 18–25

Contents lists available at SciVerse ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena

The restoration effects of black locust (*Robinia pseudoacacia* L) plantation on surface soil properties and carbon sequestration on lower hillslopes in the semi-humid region of Coruh Drainage Basin in Turkey

Turan Yüksek *

Department of Landscape and Ornamental Plants Rize University, Pazar Vocational School, 53300 Pazar-Rize, Turkey

ARTICLE INFO

Article history:
Received 10 March 2011
Received in revised form 15 September 2011
Accepted 4 October 2011

Keywords:
Semi-humid
Black locust
Soil restoration
Road slope
Carbon sequestration

ABSTRACT

This study investigated the effects of black locust (*Robinia pseudoacacia* L.) plantations on surface soil properties in eroded sand loam (SL) soils. Two land use types were selected in the semi-humid region of Artvin, Turkey: a black locust plantation area (BLP) and an adjacent non-managed site (NMS) (control site). The study used a randomized complete block design with four replications in both experimental sites. Four disturbed and four undisturbed soil samples were randomly collected at a soil depth of 0–10 and 10–20 cm in each site. When compared to Non-Managed (NMS) Site, the soil bulk density (Db) decreased from 1.35 to 1.25 g cm^{-3}, permanent wilting point (PWP) decreased from 11.50 to 9.20 (% vol.), soil penetration resistance (SPR) decreased from 1.55 to 1.20 MPa; while total porosity (St) increased from 43.28 to 47.92 (%), soil organic matter (SOM) increased from 0.88 to 1.95 (%), P_2O_5 increased from 8.50 to 12.77 ppm, Ca increased from 18.07 to 21.90 (me/100gr) at 0 to 10 cm soil depth in black locust plantation (BLP) site. Total porosity (St), field capacity (FC), plant available water (PAW), saturated hydraulic conductivity (Ksat), soil organic matter (%), soil organic carbon (%), total nitrogen (T-N), P_2O_5, Ca, Mg, and K were found to be significantly greater at the BLP site when compared to the control site; while bulk density (Db), permanent wilting point (PWP), soil penetration resistance (SPR) were found to be significantly lower at a soil depth of 0 to 10 cm. Mean St, plant available water (PAW), saturated hydraulic conductivity (Ksat), soil organic matter (SOM), soil organic carbon (SOC), total nitrogen, P_2O_5 and Ca were found to decrease significantly; while clay, Db and SPR were found to increase significantly with soil depth at both the NMS and BLP sites. The highest carbon sequestration was measured at a soil depth of 0–10 cm in the BLP site. The black locust plantation (BLP) had a positive impact on surface soil properties and carbon sequestration in eroded lower hillslopes in the semi-humid region of Coruh Drainage Basin (CDB) in Turkey. The planting of black locust might be useful in soil reclamation projects in this type of eroded sites in semi-humid regions.

1. Introduction

Land degradation and erosion are serious environmental problems, both in Turkey, and in the world. The lower part of the Çoruh Drainage Basin is one of those areas which are most seriously affected by soil and water loss in Turkey. The area of Çoruh Drainage Basin is approximately 20,000 km^2. 5.8 million m^3 (290 m^3/km^2) of sediment is transported by the Coruh River that flows through the Çoruh Drainage Basin each year (Özalp et al., 2009). Artvin province has a slopped and rough land. For this reason, the Artvin–Erzurum highway and associated side roads were constructed along the Çoruh Valley. Due to dam construction works which began in 1994 in Artvin–Erzurum highway, about 120 km section of the road was out of use and reconstruction works on the Artvin–Erzurum highway, especially the forest areas at the altitudes between 200 and 500 m, were destroyed. However, during road construction works due to site conditions, an area of more than 4000 ha was destroyed. Most of the excavated materials were storaged on the hillslopes and this resulted in land loss. Due to the ongoing construction works of the new dam, it seems inevitable that larger areas will be damaged.

It is well established that in degraded areas, soil is shallow; soil nutrients and plant available water capacity are reduced. Therefore, plant selection is of great importance for rehabilitation activities on these kinds of areas. Selected plants should rapidly grow and easily adapt to the eroded soils. In this sense, black locust (*Robinia pseudoacacia*) is one of the most important exotic tree species. Black locust can greatly improve soil properties in terms of enhanced N content and availability nitrogen (Olesniewicz and Thomas, 1999; Rice et al., 2004; Tateno et al., 2007), soil available P pools (Gillespie and Pope, 1990), soil structure and quality, root biomass, and soil organic C sequestration (Ussiri et al., 2006), and thus also improve biological properties of the soil (Xue et al., 2007). Since 1995, black locust (*R. pseudoacacia*) has been planted

* Tel.: +90 4646127315; fax: +90 4646127316.
E-mail address: turan53@yahoo.com.

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doi:10.1016/j.catena.2011.10.001

on an area of >3000 ha of lower hillslopes in the semi-humid region of Coruh Drainage Basin in Turkey.

The aim of this study was to determine the effects of *R. pseudoacacia* afforestation on soil physical and chemical properties and plant growth on lower hillslope in the semi-humid region of Coruh Drainage Basin in Turkey.

2. Material and methods

2.1. Site description and history

The study was conducted in a semi-humid zone in Coruh River in Artvin, Turkey. The study area, is located on 41° 11′ 08″–41° 11′ 17″ N and 41° 50′ 54″–41° 50′ 58″ E. The study area is characterized by a rolling topography and is highly dissected by small streams. The altitude of the area is between 220 and 380 m a.s.l. (See Fig. 1). According to the nearest meteorological station in Artvin, the climate is sub-humid, with a long-term annual average rainfall of 689 mm (although it was 880 mm in 2007), with lowest rainfall in summer (103 mm), and highest in winter (262 mm) and a mean annual temperature of 12.3 °C (Yüksek et al., 2010). According to the climate diagram of the study area prepared by Thornthwaite, there was serious water deficiency from July 15th to the end of September (See Fig. 2). The study area is relatively steeply sloping (30 ± 2%). According to International Soil Classification System (ISCS), the soils of the area were classified as brown forest soils (Anonymous, 1990).

The rock mass is extensively volcanically disrupted and the parent material is andesite. Plant cover ratio in the study area in non-managed sites (NMS) was less than 20%. The forest type of the non-managed site (NMS) consists of highly degraded *Quercus petraea* (L.), (oak coppice), *Carpinus betulus* (L.), and some herbaceous plants (*Brachypodium pinnatum* (L), *Bromus tectorum* (L.), *Avena sativa* (L.), *Poa annua* (L.), *P. trivialis* (L.), *P. nemoralis* (L.), *P. bulbosa* (L.), *Agrostis stolonifera* (L.), *Dactylis glomerata* (L.), *Cynosurus echinatus* (L.), *C. cristatus* (L.), which are spread out under the forest storey.

In order to reduce the amount of sediment transported by the river of Coruh Drainage Basin (CDB), the soil conservation and rehabilitation studies started in 1994 in these degraded oak coppice stands. Rehabilitation works of degraded oak coppice land along the Coruh Drainage Basin are very difficult and time consuming. Moreover, the rehabilitation works in these areas are quite expensive. Black locust is one the species which are most commonly used for soil rehabilitation in degraded erosion areas. Between the years of 1992 and 2009, Artvin Afforestation Administration, under the Ministry of Forests conducted afforestation activities on an eroded area of approximately 15,000 ha for rehabilitation purposes. Within the scope of these activities, terraces were established in the study area. Black locust (*R. pseudoacacia* L) was planted at a spacing of 3 m and the afforested areas on the lower hillslopes in the semi-humid region of CDB were conserved by fencing (Anonymous, 2009).

2.2. Experimental design and soil sampling

The study used a randomized complete block design with four replications at each site. Soil samples were collected from control [and adjacent non-managed site (NMS)], and black locust plantation (BLP) area in the semi-humid region of CDB in Turkey. The four disturbed and four undisturbed soil samples were randomly collected at a soil depth of 0–10 and 10–20 cm in each plot in experimental sites. A total of 64 soil samples (2 land use types × 4 replicates × 4 soil pits × 2 soil depths) were collected in June 2008. The undisturbed soil samples were collected using a steel core sampler of 98.16 cm^3 volume (5 cm in diameter and 5 cm in height). Prior to analysis of soil physical and chemical characteristics, all samples were air-dried at room temperature and the disturbed soil samples were sieved through a 2 mm soil sieve.

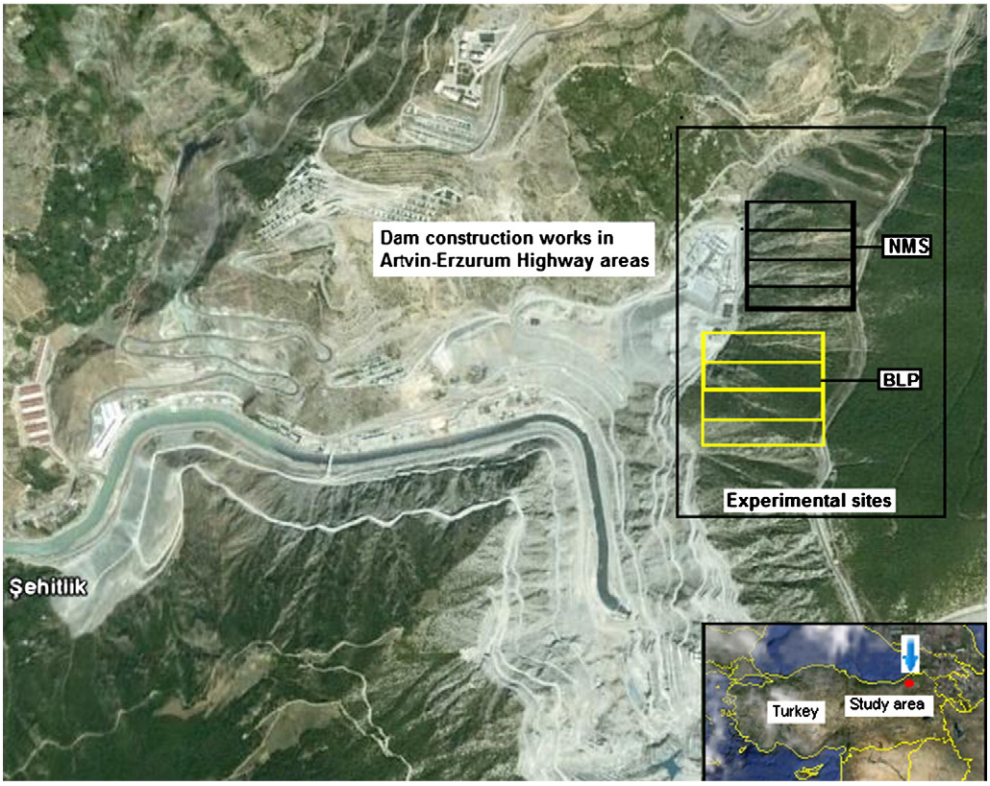

Fig. 1. Study area and experimental sites in in the study area.