Carbon Sequestration in the Leaf, Litter and Soil of *Eucalyptus camaldulensis*, *Prosopis juliflora* and *Ziziphus spina-christi* Species

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**ABSTRACT** Carbon sequestration in soil, leaf and litter of three tree species, viz. *Eucalyptus camaldulensis*, *Prosopis juliflora* and *Ziziphus spina-christi*, plantation was investigated in the Dehloran city, Iran. Results showed that the amount of sequestered C in leaf, litter and soil was significantly different among these species. The highest amount of sequestrated C was in leaf and the lowest amount in the soil. The results of this study would be useful for selection of appropriate species to develop green space and forest parks. Forest plantation of these areas would capture significant amounts of atmospheric C, and would be expected to contribute to soil quality and conservation.

**Key words:** Forest Park, Atmospheric carbon, Dehloran, Forest plantation

1 INTRODUCTION

Global warming is an important issue and caused by increasing carbon dioxide mostly due to human activity (Korner, 2003; Lal, 2004; Nobakht et al., 2011). Forests are the simple solution to reduce atmospheric carbon dioxide (Kaul et al., 2010; Tamartash et al., 2012; Ariapak et al., 2013) as compared to the artificial C sequestration methods with a relatively high cost such as filtering (Cannell, 2003). Both of the natural and artificial forests potentially able to absorb and store C dioxide from the atmosphere (Kaul et al., 2010). Forests cover about 4 billion hectares (Dixon and Wisniewski, 1995) and play an important role in C sequestration. Then, forest management, plantation and plant species are among affecting factors that influence C sequestration (Lal, 2005). There are different forest ecosystem distributed all over the world between humid to arid lands. Also, researchs have shown that afforestation in arid regions are important for C sequestration (Grunzweig et al., 2007; Suganuma et al., 2012). Moreover, some studies have evaluated the effect of tree species on C sequestration (Kirby and Potvin, 2007; Kaul et al., 2010).

Kirby and Potvin (2007) belived that preventing forest conversion to pasture had a great impact on C stock, while Lal (2005) reported that plantation, especially in arid and semi-arid regions, was an effective way to reduce C dioxide from atmosphere. Forest plantations provide many critical services such

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as C sequestration, create green space, produce timber and other forest function (Paul et al., 2002; Zarinkafsh, 2002; Updegraff et al. 2004; Panahi et al., 2011; Wang et al., 2013).

Besides different forests ecosystems and tree species, there are other factors affecting C sequestration, such as microbial activity (Hu et al., 2014; Srivastava et al., 2014), soil erosion and parent material (Shi et al., 2009), soil compaction (Saeedifar and Asgari, 2014), and deforestation (Kooch et al., 2014).

As tree species can differentially affect the soil C pool, we examined the effect of Eucalyptus camaldulensis, Prosopis juliflora and Ziziphus spina-christi on C sequestration in this study. These species are highly used in plantation all over the world and also in Iran, particularly in arid and semi-arid regions. There are some reports about the importance of Eucalyptus (Zhang et al., 2012) and P. juliflora (Bhalla and Gupta, 2013) plantation in C sequestration. Based on our literature review, there was no research about the importance of Z. spina-christi in C sequestration. Plantations with these species are important not only for forest restoration in arid and semi-arid regions but also for C sequestration (Bhalla and Gupta, 2013). Hence, understanding the potential of these species in C accumulation would help us to understand the role of each species in C sequestration.

Although the effect of some species on C sequestration has been studied in many different parts of the world (Kirby and Potvin, 2007; Kaul et al., 2010), there are little information about (1) the differences among soil, leaf and litter in C sequestration, (2) the ability of E. camaldulensis, P. juliflora and Z. spina-christi species in C sequestration in arid and semi-arid areas. So, the aim of this research was to compare the effects of leaves, litter and soil of these three species on C sequestration, and also determination of the best component for C sequestration in forest ecosystems. We hypothesized that P. juliflora had more carbon sequestered than the other two species.

2 MATERIALS AND METHODS

2.1 Study site

The study was carried out at the Abgarm Forest Park of Dehloran city in the western province of Ilam (32° 41' 18.5" to 32° 43' 20" N and 47° 19' 0.1" to 47° 16' 14.7" E (Figure 1). Established by the Natural Resource's Bureau in 1996, this park is about 476 ha and was planted at the same time with E. camaldulensis, P. juliflora and Z. spina-christi 5, meters apart from each other in about 40 ha. This region is characterized by scanty annual rainfall (320 mm) and arid climate. The average maximum and minimum temperature is 28°C and 0.6°C, respectively.

In this plantation, E. camaldulensis is taller, while the diameter of Z. spina-christi is more than the other two species. Furthermore, the percentage of canopy of P. juliflora species is more than the other species (Table 1).
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3 RESULTS

The results indicated significant differences (P<0.05) in C stock among leaf, litter and soil for the three tree species, and the leaves had the highest C stock, followed by litter and soil in all the three species (Figures 2, 3, 4).

![Figure 2 Mean (±SE) of C sequestration in leaf, litter and soil of E. camaldulensis plantation](image)

![Figure 3 Mean (±SE) of C sequestration in leaf, litter and soil of P. juliflora plantation](image)
3.1 Carbon sequestration in the litter
Since *Z. spina-christi* had no litter, data analysis only performed for *E. camaldulensis* and *P. juliflora*. Data analysis showed significant difference (p< 0.05, t = 6.28) between *E. camaldulensis* and *P. juliflora* for litter C sequestration. So that, C sequestration in the litter of *E. Camaldulensis* (41.5 g/kg) were more than *P. Juliflora* (31.8 g/kg) (Figure 5).

3.2 Carbon sequestration in the leaf
The ANOVA revealed significant difference in the amount of C sequestration among the leaves of the three species (p< 0.01 and F=45.7), the highest of which was in *Z. spina-christi*, followed by *E. camaldulensis* (Figure 6).
3.3 Soil Carbon sequestration

Analysis revealed that soil carbon stock in the stands for *P. juliflora* (31.8%) was significantly higher (p< 0.05) than that for *E. camaldulensis* (41.5%) (Figure 7).

4 DISCUSSION

Climate change in recent years, as the result of greenhouse gasses, has greatly impacted C in the ecosystems, particularly in arid and semi-arid regions. Sequestartion of C through vast green covers seems to be an ideal solution for reducing the atmospheric C (Suganuma et al., 2012). Because C sequestarion in plants by photosyntesis is the simplest and economical way for atmospheric C reduction.

Results of the current study indicated that the different species had different effects on the amount of C sequestration. *P. juliflora* had a higher level of C sequestration potential in the
soil than Z. spina-christi and E. camaldulensis. Besides the nitrogen fixing ability of some species (Paul et al., 2002) and species effects on C sequestration (Bordbar and Mortazavi Jahromi, 2007), another possible reason for this result might be due to the canopy density, as P. juliflora had the highest canopy density among the three species. Moreover, accumulation and gradual decomposition rate of litters might be another reason (Varamesh et al., 2010). According to Kraenzel et al. (2003), the C sequestration rate of the compartment soil, biomass and litter had different rates, and the wood biomass had the greatest potential for C sequestration. However, the C sequestration in the litter of E. camaldulensis was significantly higher than P. juliflora, which was consistent with the findings of other studies (Bordbar and Mortazavi Jahromi, 2007; Qorbali et al., 2014). Further, the leaves of Z. spina-christi and P. juliflora had, respectively, the highest and the lowest amount of C sequestration. It simply indicates the importance of Z. spina-christi, as an indigenous species, in C sequestration as compared to the other two non-native species. Since C sequestration is one of the criteria of ecosystem sustainability, the determination of plant species with high C sequestration capacity and also study of management factors affecting C sequestration could be a good help for land revival (Varamesh et al., 2010).

Similar to other works, our result also indicated leaf biomass had the highest portion of total sequestered C. Probably for the very same reason; most of carbon sequestration estimation methods are based on leaf biomass calculation (Honda et al., 2000). On the other hand, biomass estimation is the basis for economical carbon evaluation (McDicken, 1997). Considering the fact that soil and litter carbon are derived from the tree covers, it is necessary to study C sequestration in trees (Varamesh et al., 2010).

In our study, like another one by Varamesh (2009), there was a significant difference between plantation and barren land in C stock content, which indicated the importance of plantations in C sequestration. Different studies demonstrated that species, growth speed, site productivity, silviculture operation, tree density and diversity could have significant effects on C stock (Mortenson and Schuman, 2002; Bordbar and Mortazavi Jahromi, 2007; Mahmoudi Taleghani et al., 2008; Qorbali et al., 2014). Therefore, the differences between C stocks in studied species could be because of speed growth rate and kind of species. Furthermore, our result indicated that each part of tree species had different capacity in C sequestration. For instance, Z. spina-christi had higher C in its leaf compared to the other species, while, P. juliflora and E. camaldulensis had higher carbon sequestration in soil and litter, respectively.

5 CONCLUSION

The present study illustrated that the possibility of expanding C storage with forest plantation as an effective alternative to mitigate climate change by sequestering atmospheric carbon dioxide. Trees can accumulate a large amount of carbon from the atmosphere and play an important role for sequestering carbon in the regional, national and world scale. Therefore, selection of appropriate species based on condition of each region to increase the C sequestration potential should be carried out.

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7 REFERENCES


Kooch, Y., Theodos, T.A., Samonil P. Role of Deforestation on Spatial Variability of


ترسیب کربن در برگ، لاشبرگ و خاک گونه‌های اکالیپتوس، کهور و کنار

چکیده: ترسیب کربن خاک، برگ و همچنین لاشبرگ گونه‌های اکالیپتوس، کهور و کنار در شهر دهلران بررسی شد.

ناحیه نشان داد که مقدار ترسیب کربن در برگ، لاشبرگ و خاک به‌طور معمول در بین سه گونه متفاوت است. به‌طور معمول مقدار ترسیب کربن در برگ و کنار مقدار ان در خاک مشاهده شد. نتایج این پژوهش می‌تواند در انتخاب گونه مناسب جهت توسعه فضای سبز و پارک‌های جنگلی موثر باشد. بنابراین توسعه جنگل کاری با این گونه‌ها می‌تواند به طور معمول باعث افزایش جذب دی اسید کربن شود و همچنین می‌تواند نقش مهمی در حفاظت و کیفیت خاک داشته باشد.

کلمات کلیدی: پارک جنگلی، جنگل کاری، دهلران، کربن هوا