# Asian Journal of Plant Sciences

ISSN 1682-3974

Asian Journal of Plant Sciences 8 (2): 183-186, 2009
ISSN 1682-3974


# Effects of Removing Aerial Biomass and Density on Carbon Sequestration and Weight of *Atriplex lentiformis*

[1]K. Mahdavi, [2]A. Sanadgol, [3]H. Azarnivand, [4]S. Babaei Kafaki, [5]M. Jafari,
[6]M. Maleki and [7]A. Malekian
[1]Department of Range Science, Science and Research Branch, Islamic Azad University, Iran
[2]Scientific board of Forests and Rangelands Research Institute, Tehran, Iran
[3]Faculty of Natural Resources, University of Tehran, Karaj, Iran
[4]Department of Forest Science, Science and Research Branch, Islamic Azad University, Tehran, Iran
[5]Faculty of Natural Resources, University of Tehran, Karaj, Iran
[6]Department of Watershed, Khalkhal Branch, Islamic Azad University, Iran
[7]University of Tehran, Tehran, Iran

**Abstract:** The objective of this research was to investigate the effects of removing aerial biomass and density of *Atriplex lentiformis* plantation on carbon sequestration and biomass in a split-split plot design with three replications in Ardestan, Iran. The results revealed that the highest amount of carbon sequestration produced by treatment of 2×2 m row spacing, annual removing and control height removal. The values of carbon storage of aerial biomass, among row spacing and removal of aerial biomass treatments were significantly different ($p<0.05$). The highest carbon storage content was related also to 2×2 m row spacing and control with 60 cm height removing. None of the treatments was significantly different, concerning soil carbon storage ($p<0.05$). Moreover, the highest biomass weight was in row spacing of 2×2 m while the lowest value was recorded in 6×6 m.

**Key words:** Atriplex lentiformis, carbon sequestration, biomass, Ardestan

## INTRODUCTION

$CO_2$ is the most abundant greenhouse gas which is responsible for more than half of the radioactive forcing associated with the greenhouse effect (Dixon *et al*., 1993; Mouro-Costa, 1996). Increasing atmospheric carbon dioxide could have negative effect on the environment. Producing and creating bioenergy in the form of biofuels and electricity from crops is a practical approach to reducing $CO_2$ built up by displacing fossil fuels and sequestering carbon (Ma *et al*., 2000). The role of terrestrial ecosystem in mitigating the effects of climate change entails the assessment of carbon stocks in various pools. By different approaches $CO_2$ emissions can be reduced through carbon sequestration processes (Houghton, 1999). Although the amount of carbon sequestration per unit area in rangelands is low, their high distribution through the country, make them potential for carbon sequestration (Schuman *et al*., 2002). Vegetation plays two basic roles in this case. First the volume of atmosphere $CO_2$ may be reduced by increasing vegetation biomass. This could be potentially achieved through planting shrubs in ranges of arid and semi arid area. The second approach is to utilize vegetation as a source of row materials for energy production, usually referred to as bioenergy, which is considered a carbon-natural energy source (Van Kooten, 2000). Iran is one of the countries that obliged to decrease greenhouse gases, and one of the suitable approaches is carbon sequestration in rangeland plants. There are about 90 million hectares rangelands in Iran with high potential for carbon sequestration. At the end of 2007, about $833\times10^6$ seedling was planted in rangelands. Shrubs are known for high potential in carbon sequestration. *Atripex lentiformis* is the most common shrub used in reclamation activities in Iran (Eskandari *et al*., 2008). Atriplex species are characterized by high forage production, desertification control, restoration of degraded rangelands, preventing erosion and protecting wildlife, fuel usage, tolerance to salinity and harsh environmental conditions (Foroghian and Aghdam, 1986). Despite the important role of this plant in degraded rangelands, literature review

**Corresponding Author:** Khadijeh Mahdavi, Department of Range Science, Science and Research Branch, Islamic Azad University, Postal Code 477893855, P.O. Box 14515/775 or 14155/4933, Tehran, Iran

showed that there is no study on the role of *Atriplex lentiformis* plantation in $CO_2$ sequestration. The objective of this research then was to monitor the effects of row spacing and removing aerial biomass on biomass production and carbon sequestration capacity in arid regions of Iran.

## MATERIALS AND METHODS

Forest and Range Research Institute of Iran carried out a study on the effects of density, period of removing and height of removing aerial biomass of *Atriplex lentiformis* on its longevity and qualitative production during 1994 to 2006. In order to investigate the carbon sequestration in this species, sampling was done at the end of the study period. The study area is located 40 km northwest of Ardestan, between 33° 23' to 33° 59'N and 51° 27' to 52° 23'E. The area has a dry climate with a long term mean annual precipitation of 111.3 mm and mean annual air temperature of 20.2°C. The sandy loam soil is highly saline; PH and EC values are 7.96 and 65.18 dS $m^{-1}$, respectively (Eftekhari, 2000). *Atriplex lentiformis* was planted in a split-split plot design in three hectares area with three replications and 45 treatments in each replication over 1993. Treatments were row spacing at three levels (2×2, 4×4, 6×6 m), as main treatment, period of aerial biomass removing at three levels (annual, biennial, triennial) as sub treatments, removing the aerial biomass at five levels (control, removal from bottom, 20, 40 and 60 cm heights respectively) as sub-sub treatments. Totally 135 plant samples were cut from basal area and the fresh weigh of areal parts was determined in the field. Then, 200 g of each treatment were transferred to laboratory for dry weight as well as organic carbon percentage determination. The root and soil samples were taken from 0-30 cm depth (the depth of root penetration). The plant samples were dried in open air for determining carbon content burning at 375°C in an electric oven. The Walky and Black method was used to determine the percentage of soil carbon content (McDicken, 1997). First, data were normalized before the analysis by the one-sample Kolmogorov-Smirnov test using SAS software. Confirming the significant difference, the Duncan comparative test was applied to indicate the difference between treatment averages.

## RESULTS

The results of different row spacing, period and height of aerial biomass removal showed no significant differences in 5% confidence level on carbon content of the soil. While row spacing and removing aerial biomass treatments indicated significant difference in root carbon storage, aerial biomass carbon and biomass weight in 5% confidence level so the maximum and minimum values were observed in the row spacing of 2×2 m and 6×6 m, respectively (Table 1-3). In contrast, periods of aerial biomass removal had no significant difference in root carbon storage, aerial biomass carbon and biomass weight in 5% confidence level. Meanwhile the carbon storage content in aerial biomass was higher than root and soil in all treatments (Fig. 1).

Table 1: Root, aerial biomass carbon, carbon sequestration and aerial biomass weight in row spacing treatment

| Row spacing | 2×2 m | 4×4 m | 6×6 m |
|---|---|---|---|
| Root carbon (kg $ha^{-1}$) | 6862.5a | 1207.7b | 811.2b |
| Aerial biomass carbon (kg $ha^{-1}$) | 74583.6a | 34642.8b | 20284.6c |
| Soil carbon (kg $ha^{-1}$) | 216.0a | 243.0a | 229.0a |
| Carbon sequestration (kg $ha^{-1}$) | 81661.1a | 36092.5b | 21324.8b |
| Aerial biomass weight (kg) | 9250.0a | 3387.5b | 1761.7c |

Different letter(s) indicated the meaningful difference of 5% confidence level

Table 2: Aerial biomass carbon and aerial biomass weight in removal aerial biomass treatment

| Removal of aerial biomass | Control | Removing from bottom | 20 cm | 40 cm | 60 cm |
|---|---|---|---|---|---|
| Aerial biomass carbon (kg $ha^{-1}$) | 65906.9a | 25312.4b | 32971.9b | 40289.08c | 52574.10a |
| Aerial biomass weight (kg) | 6.8a | 1.1c | 3.7b | 4.51b | 6.73a |

Different letter(s) indicated the meaningful difference of 5% confidence level

Table 3: Carbon sequestration in removal aerial biomass treatment

| Removal of aerial biomass | Control | 60 cm |
|---|---|---|
| Average (kg $ha^{-1}$) | 70700.24a | 55779.9b |

Different letter(s) indicated the meaningful difference of 5% confidence level

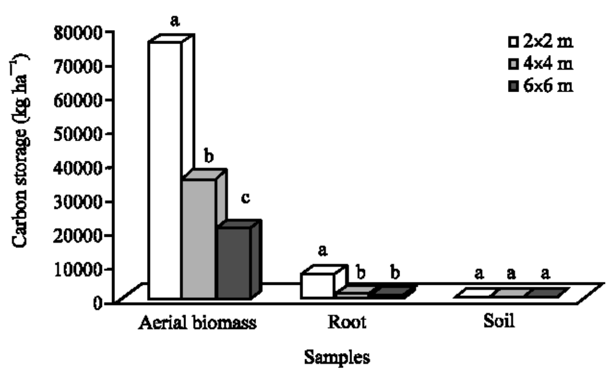


Fig. 1: The carbon storage in aerial biomass, root and soil Different letter(s) indicate significant difference in 5% confidence level

## DISCUSSION

**Effect of row spacing and removing aerial biomass on carbon storage:** The maximum amount of carbon sequestration was found in the lowest row spacing

(Table 1). As the carbon content of biomass is the index of biomass per unit area, then dense vegetation cover supports canopy cover and the content of aerial biomass. Dugas (1999) suggested that the higher carbon storage occurred when Leaf Area Index (LAI) and aerial biomass height increased. Fang *et al.* (2007) also studied the biomass production and carbon storage in *Populus* species and concluded that the amount of carbon storage in row spacing of 3×3 m was higher than 3×4, 4×4 and 4×5 m. They also mentioned that it is important to choose the best row spacing in order to gain the maximum productivity, biomass and carbon. Park and Ohga (2004) argued that maximum amount of carbon in Willow Plantings to the row spacing of 0.3×0.9 m in comparison with those of 0.3×0.3 m and 0.6×1.1 m. This study showed that removing of aerial biomass had negative effect on the aerial biomass carbon storage and carbon sequestration and the maximum amount of carbon storage was found in the control treatment while the lowest value was obtained in the treatment removed from the bottom of plants (Table 2, 3). As no stress applied on the plants in control treatment, its sufficient growth and leaf area index increased. Andrew and Gregor (2006) have studied the effect of grazing intensity on carbon storage which revealed that the amount of soil and plant carbon will be increased by decreasing of grazing intensity, because when canopy cover grows completely, more carbon will be stored in the plant. In the other hand Su-Yong *et al.* (2003) concluded that avoiding vegetation harvesting will increase the carbon storage in the soil and plant. These findings support the results obtained by investigation.

**The content of soil carbon:** As the results indicate, the row spacing, removing biomass and removing periods treatments, had no significant effect on soil carbon storage. Park and Ohga (2004) discussed that row spacing of 1.2×1.2, 3×3 m had a little effect on soil carbon and organic material in a 25 year old pine tree (Gilmore and Rolfe, 1980). They also declared that row spacing did not show a meaningful effect on soil carbon. Ma *et al.* (2000) investigated soil management impacts on soil carbon sequestration in swithgrass (*Panicum virgatum*) and suggested that row spacing and cultivar did not change soil organic carbon in the short-term (i.e., 2-3 years) after *P. virgatum* establishment. Park and Ohga (2004) stated that soil carbon content was not affected by planting spacing and harvest cycle (annual and triennial). They also indicated that although aboveground biomass differences between the two cycles was considerable but only one year cycle showed significant differences in aboveground biomass production which would not provide enough additional detritus input to the soil system to be detected in soil content differences.

**Aerial biomass weight**

**Row spacing:** Significant difference at 5% confidence level was observed between the row spacing of 2×2, 4×4 and 6×6 m, respectively (Table 1). Increase of density of shrubs per unit area in 2×2 m row spacing provided more canopy cover which resulted in increased aerial biomass weight. It is similar to findings of others researches for instance (Armstrong Johns and Tubby, 1999) concluded that the maximum productivity of 13.6 t $ha^{-1}$ was related to the row spacing of 1×1 m in comparison with 2×2 m. Moreover, Habibian and Sanadgol (2006) showed that the most aerial biomass weight in *Atriplex lentiformis* is related to 2×2 m row spacing.

**Biomass removal:** At 5% confidence level a significant difference was observed between the control and 60 cm removing heights compared to other treatments (Table 2). Since both, treatments had more branches, even the control shrubs had no new growth in the lower parts, 60 cm treatment resulted new growth in upper branches and their weight was then meaningfully different from other treatments. Eriksson (2006) reported a similar condition that unthinned treatment had the largest standing biomass for both species (*Pinus sylvestris*, *Picea abies*), which resulted that unthinned treatment is preferred if the objective is to maximize the standing biomass and the carbon storage. Also, Stegemoeller and Chappell (1991) supported the ideal that aerial biomass removing and thinning reduce growing and canopy cover in comparison with control treatment while its negative effect depends on thinning height and site quality.

## CONCLUSION

The results indicated that 2×2 m row spacing had the highest carbon storage (81. 6 t $ha^{-1}$) and decreased to 21.3 t $ha^{-1}$ in row spacing 6×6 m. On the other hand, different treatments had significant difference on root, aerial biomass weight and carbon sequestration. In all treatments, carbon storage in aerial biomass (93%) was higher than the root (6.3%) and soil (0.7%). Swamy *et al.* (2003) showed that in *Gmelina arborea* tree, the most carbon storage was in aerial biomass (83%) in comparison with root (18.51%). Based on the results of this research it is recommended to decrease the spacing row to increase carbon storage. If carbon sequestration and off setting greenhouse gas emissions is the prime motive behind planting *Atriplex* on a salt land then control treatment would be the better option of the other removing heights. Nevertheless, sequestered carbon could be a useful by-product in rangelands.

## ACKNOWLEDGMENTS

The authors are grateful to the Faculty of Natural Resource, University of Tehran for lab facilities and Department of Natural resource of Ardestan, for valuable technical assistance.

## REFERENCES

Andrew, J.E. and P.A. Gregory, 2006. Effect of grazing intensity on soil carbon stocks following deforestation of Hawaiian dry tropical forest. Global Change Biol., 12: 1761-1772.

Armstrong Johns, A.C. and I. Tubby, 1999. Effect of spacing and cutting cycle on the yield of polar grown as an energy crop. Biomass Bioenergy, 17: 305-314.

Dixon, R.K., K.J. Andrasko, F.G. Sussman, M.A. Lavinson, M.C. Trexler and T.S. Vinson, 1993. The forest sector carbon-offset projects: Near term opportunities to mitigate greenhouse gas emission. J. Water Air Soil Pollut., 70: 561-577.

Dugas, W.A., M.L. Hever and H.S. Mayeux, 1999. Carbon dioxide fluxes over Bermuda grass, native prairie and sorghum. Agric. For. Meteorol., 93: 121-139.

Eftekhari, M., 2000. Design knowledge ecologic area IRAN (vegetation cover Kashan area). Technical Report Forests and Rangelands Research Institute, Tehran, Iran.

Eriksson, E., 2006. Thinning operation and their impact on biomass production in stand of *Pinus sylvestris* and *Picea abies*. Biomass Bioenergy, 30: 848-854.

Eskandari, N., A. Alizade and F. Mahdavi, 2008. Policies of Range Management in Iran. 1st End., Pone Publishing, Iran, ISBN: 978-964-6931-93-0.

Fang, S., J. Xue and L. Tang, 2007. Biomass production and carbon sequestration potential in poplar plantation with different management patterns. J. Environ. Manage., 85: 672-679.

Foroghian, P. and H.M. Aghdam, 1986. Atriplex and its role in rehabilitation and improvement ranges Iran. Technical Report Range Technical Institute Forests, Rangelands and Watershed Organization, Tehran, Iran, No. 18.

Gilmore, A. and G. Rolfe, 1980. Variation in soil organic matter in short leaf pine and loblolly pine plantation at different tree spacing. Exp., Sta. For. Res. Report, 80: 1-4.

Habibian, H. and A. Sanadgol, 2006. Effect of thinning and row spacing on production of *Atriplex lentiformis*. Iran. J. Desert Range Res., 14: 53-67.

Houghton, R.A., 1999. The annual net flux of carbon to the atmosphere from changes in land use 1850-1990. Tellus B, 51: 298-313.

Ma, Z., C.W. Wood and D.I. Bransby, 2000. Soil management impacts on soil carbon sequestration by switchgrass. Biomass Bioenergy, 18: 469-477.

McDicken, K.G., 1997. A guide to monitoring carbon storage in forestry and agro forestry projects. Forest Carbon Monitoring Program Winrock International Institute for Agricultural Development, VA., USA., http://www.winrock.org/ecosystems/files/carbon.pdf.

Mouro-Costa, P., 1996. Tropical Forestry Practices for Carbon Sequestration. In: Dipterocarp Forest Ecosystems: Towards Sustainable Management, Zchulte, A. and D. Schone (Eds.). World Scientific, Singapore, pp: 308-334.

Park, G.S. and S. Ohga, 2004. Effect of cutting cycle and spacing on carbon content Willow. J. Fac. Agric. Kyushu Univ., 49: 13-24.

Schuman, G.E., H.H. Janzen and J.E. Herrick, 2002. Soil carbon dynamics and potential carbon sequestration by rangeland. Environ. Pollut., 116: 391-396.

Stegemoeller, K.A. and H.N. Chappell, 1991. Effects of fertilization and thinning on 8-year growth responses of second-growth Douglas-fir stands. Can. J. For. Res., 21: 516-521.

Su-Yong, Z., H.L. Zhao and T. Zhang, 2003. Influence of grazing and enclosure on carbon sequestration in degraded sandy grassland, Inner Mongolia, North China. N. Z. J. Agric. Res., 46: 321-328.

Swamy, S.L., S. Puri and A.K. Singh, 2003. Growth biomass, carbon storage and nutrient distribution in *Gmelina araborea* roxb. Stands on red lateritic soils in central India. Bioresour. Technol., 90: 109-126.

Van Kooten, G.C., 2000. Economic dynamics of tree planting for carbon uptake on marginal agricultural lands. Can. J. Agric. Econ., 48: 51-65.