How Can Contribute to Carbon Sequestration and Biodiversity in Arid Regions?

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Abstract

Global warming is the main environmental issue in which occurred during the last century. To reduce the greenhouse effects of Co2 emission, carbon can be fixed into plants skeletons as organic matter and conserved plant vegetation. In arid areas, using the saksaul (Haloxylon spp.) and remth (Hammada salicornica) species of chenopodiaceae family for reclamation of land vegetation have promise for this purpose and will be benefit to biodiversity. For determination the importance of arid areas for carbon sequestration, 114 individual plants of Hammada salicornica from seven sites and 64 individual plants of Haloxylon spp from five sites have been cut into ground level. The harvested materials disected into annual growth production (AGP) and the woody matterial production (WMP) and weighted for determination of dry matter after being oven dried. To estimate underground biomass, the roots of 10 individual plants of each species were pulled from the soil by digging the root zone. Botanical composition and wild life of a reclamated site in Sabzevar region with the Haloxylon spp. were measured compared with an adjacent area in terms of biodiversity. Results indicated that Hammada can maintain between 202 to 3645 kg/ha as total plant biomass (TPB) in the form of natural vagetation and Haloxylon between 7439 to 22075 kg /ha of TPB as planted vegetation in areas with less than 150 mm precipitation. The cost for establishment of these species is about 150$/ha in which the minimum above ground dry matter can be maintained for at least 20 to 30 years. In general conserving natural vegetation and using these species as phyto-reclamation of desert areas show a good potential perspective for carbon sequestration and indirectly improving botanical composition and providing habitate for wide life in arid regions. The ways of plantation development of these species are explained in the text.

Keywords: Haloxylon Spp., Hammada Salicornica, Biodiversity, Carbon Sequestration, Vegetation Conservation

Introduction

Global warming due to increasing the level of greenhouse gases including Co2 is the main environmental issue of the world in the new century. Fossil fuel burning and land vegetation dagredation by development of annual cultivated crops, overgrazing , range and forest clearing are the main causes of oxidation of organic carbon to Co2. This problem inforced the governments to signed international convention on climate change and the reduction of greenhouse gases.

There are three ways for management of atmospheric carbon: a- increasing the ammount of accumulated carbon by establishing the sinks by carbon sequestration, b- preventing the emmission of carbon from the sinks to the atmosphere by carbon conservation and c- reducing the demand for fossil energy by other forms of energy as carbon substitution.

In this regards, plants accounted as efficient collectors. Anderson and Coleman (1985) suggested that any actions such as increasing the cycle of carbon in plants skeleton or organic matter in the soil by decreasing the soil cultivation, changing the cultivation systems from annual to perennial plants, using fertilizing for improvement of plant growth, and selecting species with good yield and root production are effective in carbon sequestration by plants. Conversion of marginal lands to carbon seqestraton is another option in which recommended by Luciuk et al. (1999) for Canada and Lee and Dodson (1996) for the USA.

There are a vast areas in arid regions in which no cropping is possible without irrigaion. For example, in Iran about 51% of the total area of country (165 million ha) receive less than 200 mm annual rainfall on average. In this case because of goverment commitment for managing atmospheric carbon, to do this action, the question is that, is there any potential for contributing carbon sequestration and biodiversity conservation in arid regions for overall local and global benefits? This potential has been evaluated in this study.

Material and methods

Khorasan Province is located in east of Iran. A vast area in this province has arid and desert condition with mean annual ranifall of less 150 mm. Remth (*Hammada salicornica*) as a shrub plant in the form of natural vegetation, and saksaul (*Haloxylon persicum, H. aphyllum* and *H. ammodendron*) as semi-shrub plant in the form of natural and transplanted vegetation are accounted as two main dominant species in desert regiongs of this province. Both species belong to Chenopodiaceae family. Hammada grows in warm area but Haloxylon adapted to warm and cold areas.

For determination of above-ground biomass (AGB), 114 individual plants of Hammada from seven natural vegetation sites including 24plants from Jems, 15 plants from each sites of Dehshur, Halvan, Khosrowabad and Daihuk of Tabas region, 15 plants from Khusf of Birjand and 15 plants from Sefarsakh of Nehbandan, and 64 individual plants of *Haloxylon persicum* from planted areas of five sites including 20 plants from Baimorgh, 10 plants from each sites of Ghogd, Sardagh, Omrani and Nodehpashank of Gonabad region have been cut into ground level near to the seed maturity. The above-ground material separated for annual growth production (AGP) as green folliage, and brunches and stems as woody material production(WMP) and then taken to the laboratory, dried in oven for one week at 75° C and weighted for determination of dry matter.

Number of plants per hectar of *Hammada* counted by using 4 quatrates of 50 by 4 meter and for *Haloxylon* by using 3 quatrates of 50 by 20 meter in each site and used for calculation of plant biomass per hectar. The contribution of other plants biomass in *Hammada* and *Haloxylon* vegetation types including perennial plant accounted by cutting them also into ground level and considerd as production of companion species (PCS).

To estimate the below ground biomass (BGB) or root biomass of both species, 10 individual plants of each of the above mentioned species were selected for determination of root dry matter in which the roots of each plant pulled from the soil by digging the root zone. Root matterial was dried as mentioned for above-ground. The mean of root dry matter of each species, were used for estimation of BGB/ha in each measurment site by using the root to shoot biomass coefficient. Total plant biomass(TPB) for each species calculated by adding the amount of BGB to AGB. The total above ground vegetation biomass (TAGVB) of each site obtained by adding PCS to TPB.

Methods of plant establishment of these species have explained from available experiences in which are used in this province.

Botanical composition of a reclamated land with *Haloxylon* plantation in Sabzevar region compared with non-reclamated land in adjacent area by identification and recording the main perennial species. Some wildlife in this habitate also recorded.

Results

Plant biomass

The results from seven measured sites of Hammada salicornica are shown in Table (1). There are differences between sites for all measured parameters. In general, the amount of AGP of Hammada obtained from 67 to 1162 kg/ha in different sites. The amount of AGB shows a range of 146 to 2642kg/ha in study areas in Hammada natural vegetations. The site of Jems shows the highest and the site of Sefarsakh the lowest amount of above and below ground biomass. The root to shoot ratio obtained about 0.38 on average for Hammada. Other perennial plant biomass in these sites range from 28 to 2510 kg/ha. Total above ground vegetation biomass of Hammada vegetation types chaneged from 201 to 5152kg/ha in different sites.

Results obtained from planted Haloxylon vegetation in five sites have been shown in Table (2). The lowest and the highest WMP, AGB, TPB and TAGVB are obtained from Baimorgh and Ghogd respectively. Root to shoot ratio of Haloxylon became about 0.46 by calculation mean of 10 individual measured plants. This plant maintained between 7933 to 20540 kg/ha of TPB in measurment sites. Also its foliage as AGP ranged from 1055 to 4190 kg/ha.

Botanical composition

Botanical composition of reclamated site by Haloxylon has been compared by adjacent site by recording some of important perennial species of both sites (Table 3). As the results show, there are about 10 perennial species in established Haloxylon site and 5 perennial species in adjacent site. Botanical composition of the last site are unplatable and with low density.

Wildlife

In reclamated site, some wildlifes such as wolf, fox, rabit, porcupine, tortoise, mouse, jackal, lizard, snake and sparrow-hawk are obviously observed.

Planting methods

Naturally both species regenrate by seed and have regrowh after even cut from ground levels. For plantation development of Haloxylon, It is needed to grow it first in the nursury and after a year, seedling transplanted as bare root or pot planting to the farm. Hammada needs to grow in pots in the nursury and then transplanted for plantation development. After transplanting, it is recommended to irrigate them deeply for each time during the first and even the second year for good establishment and deep rooting system development. These plants grow well in areas with more than 100 mm rainfall per year after establishment and don't need any irrigation. The reclamated lands should be excluded from grazing for three years. The experiences indicated that light to moderate grazing or browzing in winter time is suitable for plant vitality and longivity.

Discussion

Differences between dry matter harvested in different sites are mainy due to different soil textures. As the soil become lighter texture, number of plants/ha are reduced and the plant size become smaller.

According to the view of scientists eg. (Ayoub and Malcolm 1993, Datjes 1998, Werwij and Emmer 1998), one option for managing atmospheric carbon is increasing carbon accumulation in the sinks by carbon sequestration in natural ecosystems and agriculture sectors. In this respect however, forests are the most obvious example for carbon sequestation, but the arid region also has perennial plants as shrubs and trees which may contribute to carbon sequestration. For example, in this study *Hammada salicornica* and *Haloxylon spp.* are two well adapted species in arid region that accumulate considerable amount of dry matter in their skeleton in region with less than 150 mm of rainfall on average. Hammada between 0.2 to 3.6 t/ha as natural vegetation and Holoxylon between 7.4 to 20.5 t/ha as planted vegetation. At present these vegetation grazed by animals throught the year. In fact by better management of plant vegetation by light to moderate grazing in propper time, plant vitality, longivity and dry matter acumulation increased (Tavakoli et al. 2005) due to controlling and reducing deseaes and pests density. It also made a balance between shoot and roots in terms of soil moisture limitation.

There is a comment that for effective carbon sequestration, organic matter should be lasted for at least 100 years (Glenn et al 1993, Niskanen et al 1996). The physiological life of Hammada is between 15-20 years (Tavakoli et al. 2005) and for Haloxylon between 20 to 30 years (Amani and Parvizi 1996). Because of water limitation in arid region, degradation of organic matter is low and it would be expected that organic matter lasted for longer time as sequesterd carbon in arid areas. Also, the soils in arid areas have low organic matter and accounted as a good sink for dry matter accumulation.

More diverse species in reclamated site (Table 3) is due to better management conservation. Most of species has been removed from non-reclamated site by overgrazing. The reclamated site has provided more food and safe shelter for wildlife.

The usefulness of these species is that they have multiple regeneration sterategi; from seed and also rejuviend after clear cutting (Tavakoli et al., Amani and Parvizi 1996). So, development of plantation area by these two species and by conserving vegetation propperly, the local pepole benefit of controling wind erosion, improving their socio-economic condition by preparing more forage for animals and globally this action resulted to more carbon sequestration in improving biodiversity. Plant biomass appears to be also one of the more promissing renewable energy sources and substitution for part of fossil fuel.

The cost of establishing new vegetation of Haloxylon and Hammada in Khorasan Province is about 150$/ha. If we consider to the the mean dry matter accumulation in the skeleton of Haloxylon about 12512 kg/ha for about 30 years and for Hammada of 2452 kg/ha for 20 years, the cost of maintaining these amount of dry matter per year would be 5 and 7.5 $ per year respectively. In Iran, the land area for carbon sequestration perpose is at least 10 million ha.

Conclusion

Arid areas have limitation sor arable croping because of water availability limitation. This ecosytem is susceptible to land disturbance, grazing pressure or cultivation. So the logical and economical manner is to rehabilitate the degraded areas by such as the mentioned species and devoted arid lands for carbon sequestration. Definitly developing this action needs national and international aids and cooperations.

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Table 1: Dry matter production (kg/ha) of *Hammada salicornica* in different sites

Sites	AGP	WMP	AGB	BGB	TPB	PCS	TAGVB
James	1162	1480	2642	1003	3645	2510	5152
Dehshur	335	341	676	257	933	135	811
Halvan	423	377	800	304	1104	112	912
Kurit	451	570	1021	388	1409	235	1686
Daihuk	341	407	748	284	1032	112	860
Khusf	92	93	185	70	255	28	212
Sefarsakh	67	64	146	56	202	55	201
Mean	410	476	888	337	1226	455	1405

Table 2: Dry matter production (kg/ha) of Haloxylon in different sites

Sites	AGP	WMP	AGB	BGB	TPB	PCS	TAGVB
Gonabad	4190	9879	14069	6471	20540	130	14199
Sardagh	2278	10462	12740	5860	18600	149	12889
Baimorgh	1581	3514	5095	2344	7439	252	5347
Omrani	1055	4459	5514	2536	8050	310	5824
Nodehpashang	1745	3688	5433	2500	7933	137	5570
Mean	2170	6400	6050	3942	12512	196	8766

Table 3: Botanical composition of reclamated and non-reclamated sites in Sabzevar (Appeareance-A, Non appeareance-N)

Species	Reclamated site	Non-reclamatead site
Holoxylon persicm	A	N
Salsola richteri	A	N
Calligonum sp.	A	N
Stipagrostis spp.	A	A
Astragalus squaresus	A	N
Peganum harmala	N	A
Prosopis sp.	A	A
Artemisia seiberi	A	A
Convolvous sp.	A	N
Smirnovra iranica	A	N
Alhagi pseudoalhagi	A	A