沙漠研究 **19**-1, 49- 52 (2009)
Journal of Arid Land Studies

Observation of Effects of Tree Planting on Local Climate in the Central Part of the Taklimakan Desert, China

Mingyuan DU[1], Hongwu CHEN[2], Jiaqiang LEI[3], Xinwen XU[3] , Shengyu LI[3], Qing HE[2]

Abstract: Tree or shrub planting has been carried out in some basins in the central part of the Taklimakan desert since 2003. In order to clarify the true effects of tree planting on local climate, intensive micro-meteorological observations were made. Several stations were set up in 2003 and 2004, respectively. Observation shows that there was an air temperature inversion occurred during nighttime in some basins in the central part of the Taklimakan desert. And, this inversion was stronger on a calm night than a weak wind night. When wind speed is very weak or when it is calm, inversion in the tree planted basin will become stronger than that without tree planting. Tree plating will directly reduce wind speed and increase humidity and therefore accelerate the temperature inversion. Tree planting or land cover change will indirectly decrease air temperature in a complex topography.

Keyword: Local climate, Taklimakan Desert, Temperature inversion, Tree planting

1. Introduction

The Taklimakan Desert is a major sandy desert in the world. Prior to the advent of petroleum exploration in the 1990s', there was no settlement in the central part of the desert due to lack of drinking water. Because of petroleum exploration, people have made desert road through the central part of the desert to set up many communities there. In order to improve the living condition in these communities, tree or shrub planting has been carried out since 2003 by using underground salty water. It is well known that greening is very important in urban areas as reviewed by Givoni (1991). However, it is rarely practiced in the countryside, especially in desert regions. There is almost no literature for desert areas. On the other hand, the impact of vegetation changes on local and regional climates has received considerable attention since the mid-1970s' ((e.g. Jackson and Idso, 1975; Courel *et al*., 1984; Balling, 1988, 1991; Du, 1996; Du *et al*., 1996). Many investigators have found that a decrease in vegetation cover reduces evapotranspiration thereby allowing an increase in local temperature levels. Balling (1988, 1991) revealed that severe overgrazing and resultant land degradation in the semiarid areas of northern Mexico created significantly higher temperatures in the border area and suggested that any greenhouse -driven desertification may amplify regional and global warming. On the other hand, when an oasis is developed in a desert area, the local climate will be changed somewhat. It was revealed that expansion in the area of oases, and increase in windbreak forests have caused an increase in precipitation and decreased summer air temperature in the western part of the arid region of China, especially in the Taklimakan Desert (Du, 1996; Du *et al*., 1996; Du and Maki, 1997). Kurose *et al*. (1998) showed that air temperature decreased by 5˚C and relative humidity increased by 14% when entering into an oasis from a desert. However, all these oases are located around the boundaries of the desert and not in the central part of the desert. The purpose of this paper is to discuss the possible effects of tree or shrub planting on the local climate as land cover change in the central part of Taklimakan Desert.

2. Materials and Methods

2.1 Description of the research area

Fig. 1 shows the research site at Tazhong (about E83˚40', N39˚00') in October 2003. Trees or shrubs have covered all the sand dunes or sand hills within the site after the spring of 2004. The trees were *Tamarix* L., *Elaeagnus angustifolia* L. and *Haloxylon ammodendron* Bge. Tree height was about 40 cm to 100 cm. Therefore, the land cover had changed completely. The tree planting area was about 2 km in radius. Three types of sand dunes exist in the Taklimakan Desert, namely compound/complex crescent dunes and crescent chains, compound dome dunes and compound/complex linear dunes. It was

[1] National Institute for Agro-Environmental Sciences, 3-1-3 Kannondai, Tsukuba, 305-8604 Japan.
[2] The Meteorological Bureau of Xinjiang Uigur Autonomous Region, Urumqi 830002, China.
[3] Xinjing Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi 830011, China.

Fig 1. Research site showing the tree planting and the basin topography. The meteorological observatory is near the tower in the center of the picture.

observed that the community is located between the compound/complex linear dunes just like in a small basin. The surrounding sand dunes were about 200 m to 300 m higher than the basin bottom. A meteorological station (Tazhong) is located just in the basin bottom as shown by the tower in the center of Fig. 1.

2.2 Observation

In order to clarify the effect of tree planting on wind, air temperature and humidity, 2 simple stations were set up at different sites: at the top of the sand dune, on windward side on sand dunes or on the leeward side of sand dunes, in the tree-planting field etc., respectively in August 18 to 30, 2003 by using DAVIS650 weather stations.

In order to clarify the true effects of tree planting on the climate, an intensive micro-meteorological observation was made in October 10 to 12, 2004. Three stations were set at Tazhong. One was at the planted basin bottom near the Tazhong meteorological observatory (E83˚40', N39˚00'). Another was set at a same kind of nearby basin bottom but without tree planting. The third station was set near a top of surrounding dunes between the two basins (230 m higher than the two basin bottoms). Air temperature at 1 m and 50 cm, humidity at 1 m and ground surface temperature were measured with one hour's time interval by using Hobo H8 pro data logger (Onset Computer Corporation).

3. Results and Discussion

Observations in 2003 showed that wind speed at Tazhong meteorological station was lower than that at the top of the sand dune and the sides without tree planting whether windward side or leeward side. However, it was higher than that in the tree planted field. The average ratios of wind speed between Tazhong and top of the sand dune, Tazhong and windward side, Tazhong and leeward side and Tazhong and tree planted field, were 0.56, 0.64, 0.68 and 1.83, respectively. Relative humidity at Tazhong meteorological station was higher then the top of the sand dune. However it does not differ much with the sides. Relative humidity was higher within the basin.

Figs. 2 and **3** shows two-case comparisons of diurnal variations of air temperatures and humidifies in tree planted and unplanted basins and also on the dune top of the two basins within two days. One case was a calm night (wind speed at Tazhong meteorological station was lower than 0.2 m/s) on October 11 to

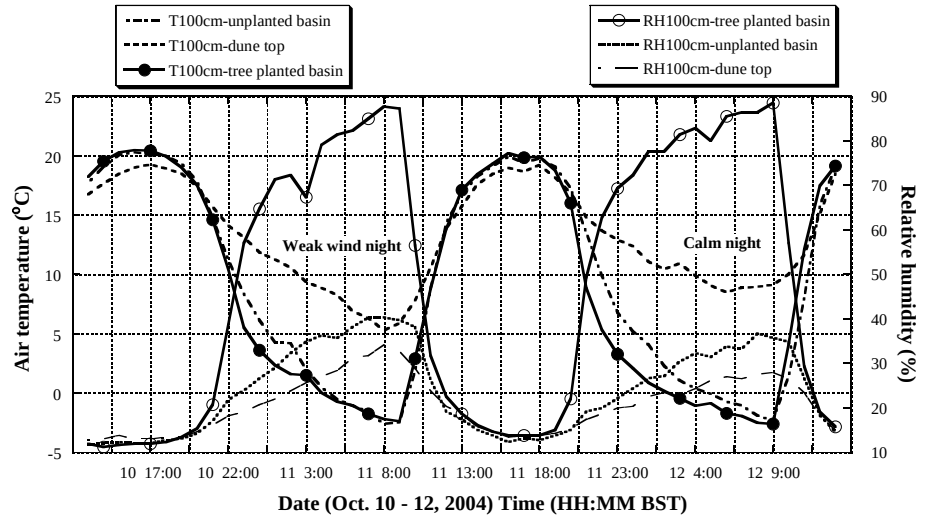

Fig. 2. Comparisons of diurnal variations of air temperatures (T100cm) and relative humidifies (RH100cm) in a tree planted basin and an unplanted basin and on the dune top of the two basins.

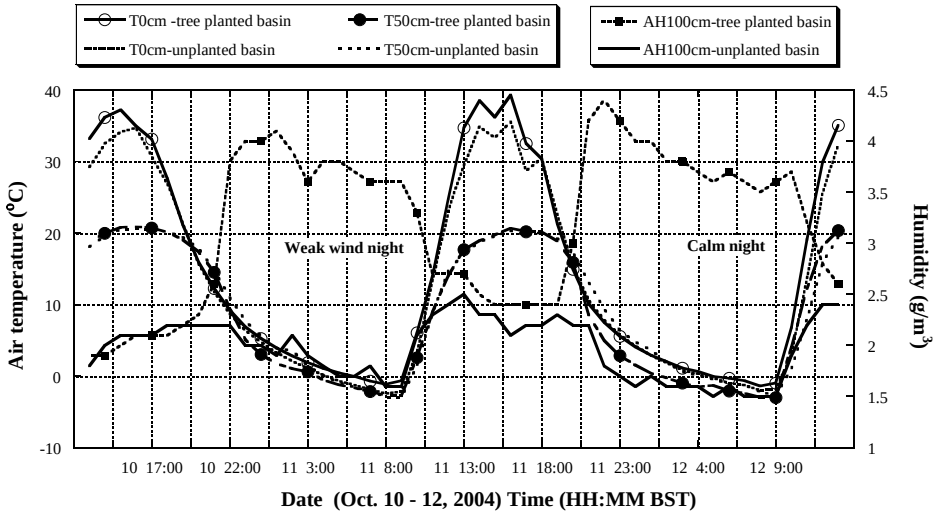

Fig. 3. Comparisons of diurnal variations of air temperatures (T50cm), surface temperature (T0cm) and absolute humidifies (AH100cm) in a tree planted basin and an unplanted basin.

12, and another was a weak wind-blowing night on October 10 to 11 (wind speed at Tazhong meteorological station was between 0.3-1.5 m/s). There was an air temperature inversion during the night, which became strongest in the early morning on comparing air temperatures between basins and the dune top. And, this inversion was stronger on the calm night (about 11.6 ˚C) than the weak wind case (about 7.8 ˚C).

Temperatures from the ground surface to 50 cm and 1 m also showed the same inversions at the two basin stations as shown in Figs 2 and 3. On the calm night, the air temperature at 1 m was lower in the tree-planted basin than that in the unplanted basin from 19:00 to 9:00. Therefore daily mean temperature (from 12:00 on October 11 to 12:00 on October 12) was 0.9˚C lower than that in the unplanted basin. However, for the weak wind case on October 10 to 11, this temperature inversion only occurred from 22:00 to 4:00. Daily mean air temperature was only 0.4 ˚C lower than that in the unplanted basin. This means

that when the wind speed is very weak or when it is calm, inversion in the tree planted basin will become stronger than that without tree planting. Tree planting will directly reduce wind speed and therefore accelerate the temperature inversion. Tree planting or land cover change will indirectly decrease air temperature in a complex topography. From Figs. 2 and 3, it can also be observed that the humidity in the tree planted basin was much higher than that in the unplanted basin, especially for the calm night. Daily mean relative humidity on the calm day was 28% higher than that in the unplanted basin. In addition to the relative humidity, the absolute humidity in the tree planted basin was higher than that in the unplanted basin.

Although the direct effects of the green area have been relatively well studied, the role that tree planting plays in altering local climate system such as temperature inversion in a basin is poorly understood. Tree planting in the Taklimakan desert started only several years ago. The trees are still young and very short. Therefore, changing of local climate was not as much like as that showed by Kurose *et al*. (1998) and Du and Maki (1994). However, These trees plating has changed the local atmospheric environment as shown by the monthly mean data of the meteorological stations in the Taklimakan Desert.

It should be mentioned that the social functions of tree planting in desert areas such as the central part of Taklimakan desert are much more important than that of urban parks. From the green area, people can get recreation and relaxation not only physically but also mentally, from their difficult life in the desert. Living conditions in the desert has become much better after the tree planting.

4. Conclusions

Tree planting at the central part of the Taklimakan Desert has reduced wind speed and increase humidity. Tree planting decreases air temperature especially when temperature inversion exited at nighttime. Daily mean air temperatures were 0.4 to 0.9˚C lower and relative humilities were about 30% higher in tree planted basin than that in the unplanted basin. And these effects were more clearly during nighttime due to a temperature inversion exited in the basin.

Our results illustrate the importance of understanding both direct and indirect effects of tree planting in desert area with complex topography, and provide a basis to understand potential interactions between tree planting and complex topography in a desert area. The challenge will be to verify these effects in the Taklimakan Desert over spatial and temporal scales of tree planting that are still continuing.

Acknowledgements

This research was partially supported by Special Coordination Funds for Promoting Science and Technology of Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan (2000-2004) and by Grant-in-Aid for Scientific Research (A) of the Ministry of Education, Science, Sports and Culture, 19255017, 2007.

References

Balling R.C. JR. (1988): The climatic impact of a Sonoran vegetation discontinuity. *Climate Change*, **13**: 99-109.

Balling R.C. JR. (1991): Impact of desertification on regional and global warming. *Bull. Amer. Meteorol. Soc.*, **72**: 232-234.

Courel M.F., Kandel R.S., Rasool S.I. (1984): Surface albedo and the Sahel drought. *Nature*, **307**: 528– 531.

Du M., Maki T. (1994): Climate differences between an oasis and its peripheral area in Turpan, Xinjiang, China. *JIRCAS Journal*, **1**: 47-55.

Du M. (1996): Is it a global change impact that the climate is becoming better in the western part of the arid region of China. *Theoretical and Applied Climatology*. **55**: 139-150.

Du M., Yoshino M., Fujita Y., Arizono S., Lei J., Maki T. (1996): Climate Change and Agricultural Activities in the Taklimakan Desert, China in Recent Years. *Journal of Arid Land Studies*, **5**: 173-183.

Du, M. and T. Maki (1997): Relationship between oases development and climate change in Xinjiang, China in recent years. J. Agric. Meteorol., 52: 637-640.

Givoni B. (1991): Impact of planted areas on urban environmental quality: A review. *Atmospheric Environment*, **25**: 289-299.

Jackson R.D., Idso S.B. (1975): Surface albedo and desertification. *Science*, **189**: 1012–1013.

Kurose Y., Tang L., Ohba K., Maroyama A., Maki T. (1998): Variation of air temperature and relative humidity from a desert to an oasis in Turpan, China. *J. Agric. Meteorol.*, **54**: 337-343. (in Japanese with English abstract).