XVII[th] World Congress of the International Commission of Agricultural and Biosystems Engineering (CIGR)

Hosted by the Canadian Society for Bioengineering (CSBE/SCGAB)
Québec City, Canada June 13-17, 2010

THE RELATION BETWEEN NON-IRRIGATED PLANTING AT SANDY LAND AND MICROMETEOROLOGICAL ALLEVIATION IN NINGXIA, CHINA

TAICHI MAKI[1]

[1]T. MAKI, Aliance for Research on North Africa (ARENA), University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8572, Japan, maki.taichi.fe@u.tsukuba.ac.jp.

CSBE100362 – Presented at Section I: Land and Water Engineering Conference

ABSTRACT Yellow sand comes mainly from the desert area in China and Mongolia. Yellow sand has increased abnormally from 2000 to 2002, and its level remains fairly high. We hope to decrease the transportation of yellow sand. The purpose of the experiment was to determine the effect of yellow sand on the microclimate by planting trees on arid dry land that had no vegetation. Trees were planted for the experiment in Daquan, Lingwu, Ningxia in North-western China. Differences in vertical profiles of micrometeorological elements based on the variety and density of plant vegetation, and micrometeorological elements of modification were affected by the tree form and leaf distribution of the covering vegetation. The author investigated the changes in the surface layer based on the difference of trees in a planted area from 2004 to 2008. The variations of air temperature and relative humidity comprising the microclimate, that affected the surface vegetation of an experimental tree-planting area, were obtained. Meteorological differences were found in the surface vegetation, but it was not clearly identified in the difference of planting trees in 2007. These effects on the microclimate of the planted field were clear. A technique to increase the rates of root taking by planting, even under non-irrigated conditions needs to be developed. It was possible to cultivate a high density of trees and to apply a non-irrigated planting system at Ningxia, China and Mongolia, and this represent an important achievement.

Keywords: Non-irrigated planting, Micrometeorological alleviation, Air temperature, Relative humidity, China.

1. INTRODUCTION

Yellow sand comes mainly from the desert area in west and middle China and Mongolia. The amount of yellow sand from these areas has increased recently and it is having many detrimental effects on the environment. It causes a dust problem, lowers visibility, and wears down machine parts, etc. Positive effects are only enriching several micro nutrients in the sea and neutralizing acid rain of air pollutants. Yellow sand was increased abnormally from 2000 to 2002, and after that it decreased, but not very much. Its level remains fairly high now, so there is concern about its effects. We have to decrease yellow sand quickly, but it takes time, and this is not easy to do. However in the near future, we strongly hope to decrease the transportation of yellow sand.

Co-researchers including the author applied for procedure to plant trees for the experiment in Daquan, Lingwu, Ningxia Huizyu Zizhiqu, in the arid land area of in Northern China, and started the meteorological investigation in 2004 and finished in 2009. The purpose of the experiment was to determine the effect of yellow sand on the microclimate by planting trees on arid dry land that had no vegetation.

2. OBSERVATION AND ANALYSIS METHODS

The general meteorological observation was carried out from 2004 to 2008. The data were gathered by the automated data acquisition instruments of “Ondotori” at Daquan, Lingwu, Ningxia in China.

The meteorological sensors sheltered from sunshine and rain, were set at the height of 1 m above the ground surface. The data were gathered every hour, and the maximum and minimum air temperatures were obtained from Sep. 2006 to July 2007, that is, almost 1 year. The micrometeorological observation was carried out from 16 September 2006 to 11 July 2007.The analysis on the data collected in 2007 was focused in this experiment result.

Observation points were selected for the purpose of looking for differences in planting trees and surface conditions. Micrometeorological measurement was carried out from 11:00 on July 9 to 11:00 on July 11, 2007, in the arid natural area of sandy land, the artificial area planted with trees, and the artificial area set a straw mat network or checkerboard.

The observation results are shown in Fig. 1 to Fig. 2. In the figures, the time of day shows at 0:00 on July 10, and July 9 shows as a negative number, and July 11 shows from 24 (24:00) as 0:00 to 35 as 11:00 July 11.

The other results were reported on Report on the Recovery of Vegetation and Protection from Yellow Sand by Planting by Maki (2005 to 2009).

The planting trees shown in Huang (2008) are as follows: No. 5 is the control plot. The trees planted in No. 6, No. 9 and No. 10 are *Caragana korshinskii* and *Hedysrum scoparium*, and in No. 11 *Atraphaxis bracteata*. The number of planting trees in No. 6 was planned as 1666, (833+833), but actually 1171 pieces were planted, and 72 pieces taking root (6.1%), No. 9 total 2499 (1666+833), actual 2524 pieces, with 637 pieces taking root (25.1%), No. 10 total 1388 (833+555), actual 1474 pieces, with 376 pieces taking root (25.5%), and No. 11 total 3333, actual 2160 pieces, with 65 pieces taking root (3.0%).

As the numbers show, the taking-root rate was very low. The trees were planted with a non-irrigated planting system. This is the purpose that we are hoping to use such a planting method. Paragraphs are all in "Normal" style and start on the same line as the heading. Write your heading and text continuously in Normal style and then, select your heading and apply the proper heading style.

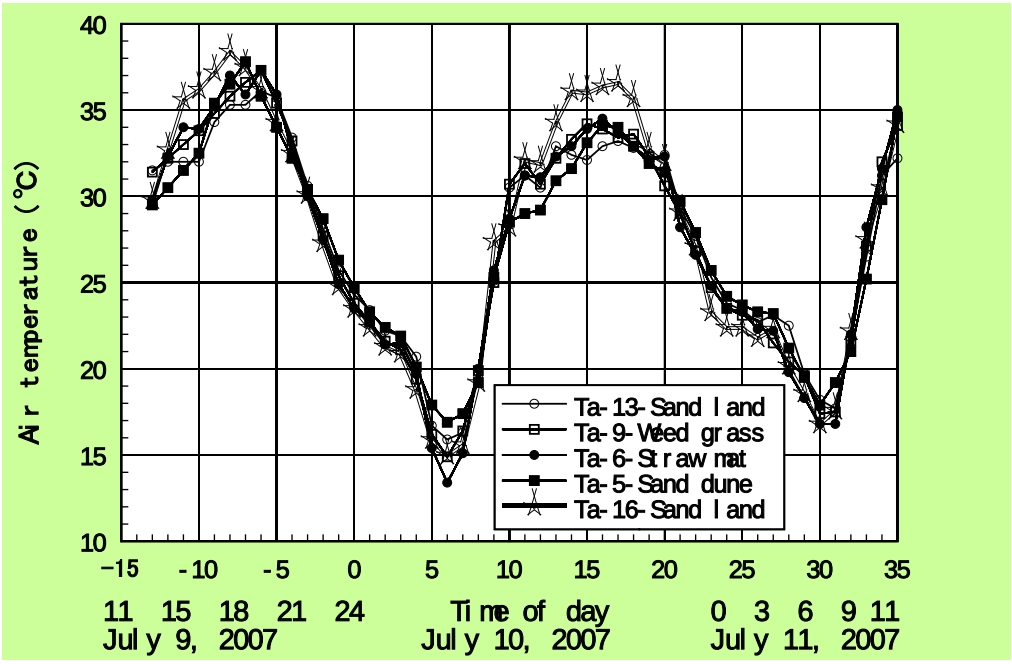
3. RESULTS AND DISCUSSION

3.1 Variation of air temperature

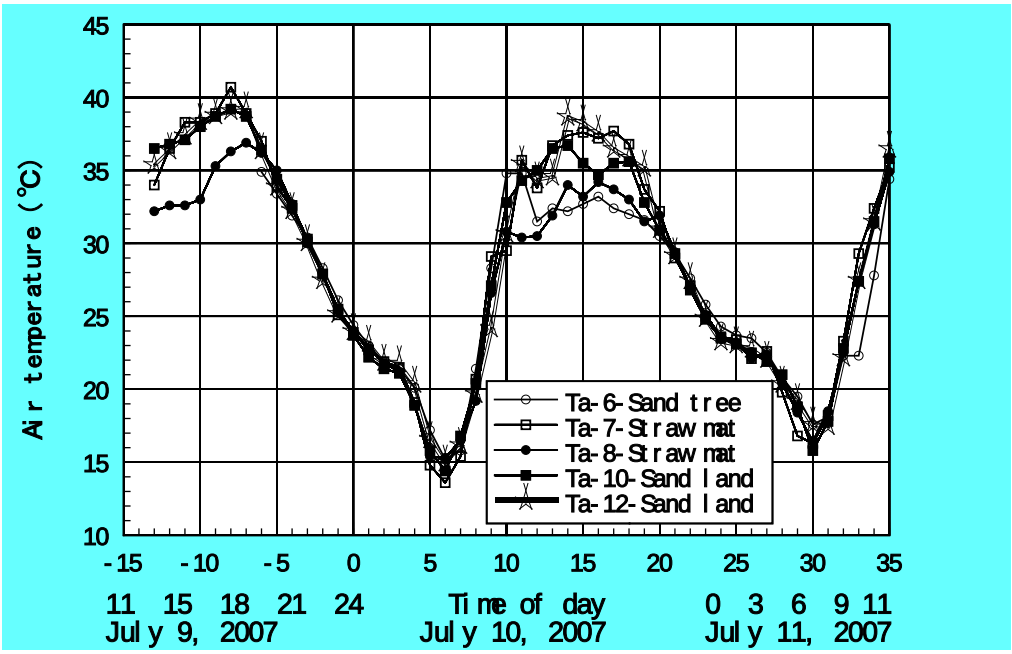
The highest recorded air temperature was 40.7℃ at No. 7 in the straw mat network at 16:00 on July 9, the second-highest was 39.2℃ at No. 10, the third was 39.1℃ at No. 12 and the fourth was 38.4℃ at No. 16. On July 10, the highest recorded air temperatures were 38.7℃ at No. 12, 37.6℃ at No. 7, 36.7℃ at No. 10 and 36.6℃ at No. 16. These recordings show that wind speed decreased by the effects of planting and straw mat, and by the roughness of the small topography around the area. On the other hand, the solar radiation was absorbed in the soil and the heated air accumulated around the area.

The lowest recorded air temperature of the maximum in the day time was 36.1℃ at No. 13 and the second-lowest was 36.9℃ at No. 8 on the day when the maximum air temperature was observed. The lowest air temperature in the daytime from 11:00 to 14:00 was 34.1℃ at No. 5 in a sand dune area that served as the control plot, and 34.2℃ at No. 8 in an area of straw mat (straw mat). On July 10, the lowest recorded of the maximum air temperature in the day in the field was 33.2℃ at No. 13, and the second-lowest recorded temperature was 34.1℃ at No. 5. At No. 6, a sandy area with dry-resistant trees, the rising air temperature early in the morning was significant, and the warm air stayed around the area where trees were growing. The maximum air temperature was 34.8℃ at 10:00, but in the afternoon the air temperature decreased pretty fast because the plot was covered by trees and the sunshine was cut by shadow. The rate of temperature increase was high from 8:00 to 11:00 during strong sunshine, and reached a peak at 10:00, but the air temperature decreased from 14:00 to 18:00 and was lowest from 17:00 to 18:00. The changes in temperature were very significant and characteristic, based on the decrease by the effect of sensitive energy of transpiration from the stomata of tree leaves. On July 9, the maximum air temperature was 33.2℃ at No. 13 and 34.2℃ at No. 9.

On the other hand, at No. 6 (sand tree) in sandy area with trees in the morning between 5:00 and 7:00 on July 10 and 11, the air temperature was the highest in all areas, matching the phenomenon in RH explained in Section 3.3. The high minimum air temperature and low maximum air temperature in the day time are affected by the wind speed and the location, at a low-level area on the north side of the sand dune, with relatively little sunshine and a fairly strong dry wind blowing across the dune area. Heat energy was removed from the sand surface by the wind, leading to low air temperature. And the low air temperature was based on the sand with high moisture content in the sand dune, but in the night time it presumed that the heat was being held and the air temperature was high, and the heat transportation by high wind advection from other areas affected the surface layer around the sand dune area. The lowest air temperature in the morning was recorded on July 10, and it was 13.4℃ at No. 6 in straw mat. Other low temperatures were 13.6℃ at No. 7 in straw mat, 14.4℃ at No. 10 in a sandy area and 14.9℃ at No. 9 in grass land, and on July 11, the lowest temperatures were 15.8℃ at No. 10 in sandy land, 16.3℃ at No. 7 in straw mat and 16.4℃ at No. 8 in straw mat.



(A)



(B)

Figure 1(A), 1(B). Variations of air temperatures at Daquan, Lingwu, Ningxia, China, from 11:00 on July 9 to 11:00 on July 11, 2007.

No. 5: Ta-5-Sand dune, No. 6: Ta-6-Straw mat and Ta-6-Sand tree, No.7: Ta-7-Straw mat, No. 8: Ta-8-Straw mat, No. 9: Ta-9-Weed grass, No. 10: Ta-10-Sand land, No. 12: Ta-12-Sand land, No. 13: Ta-13-Sand land, No. 16: Ta-16-Sand land.

At No. 16, which is sandy land, the air temperature was lowest from 23:00 to 1:00, which was the result of radiation cooling based on very weak wind in the night. Higher air temperatures included 17.9℃ at No. 5, which is sandy land, and 17.7℃ at No. 13. Other areas had temperatures around 17.5℃.

In general, from sunset to sunrise, the air temperatures were almost the same from area to area. This is typical variation in the case of weak wind over arid land, with occasional exceptions.

3.2 Variation of relative humidity

RH was the lowest at No. 5 at 3.0% on July 9 and 2.0% at 15:19 on July 10. The RH at No. 5 is lower than that in areas in the daytime and the night time. The maximum value at No. 5 was 10.1%, followed by 14.9% at No. 16, where it was dry the whole day on July 9. RH was 4.1% at No. 16, which is sandy land, on July 9, and 5.0% on July 10. On the other hand, the RH was 33.9% at No. 6, a straw mat area, and 41.2% at No. 9, which is weed grass land.

The highest RH was 82.5% at No. 7 at 6:00 on July 9, followed by 72.9% at No. 10, which is sandy land, and 72.7% at No. 12, which is sandy land and 69.4% at No. 8, which is a straw mat area. RH ranged from 60% to 70% at No. 6, No. 7 and No. 8. The highest value on July 11 was 64.3%, followed by 61.7% at No. 10, 56.5% at No. 8 and 56.3% at No. 12 in the daytime. No. 7, a straw mat area, was low at 6.3% at 16:00 on July 9 in very dry condition.

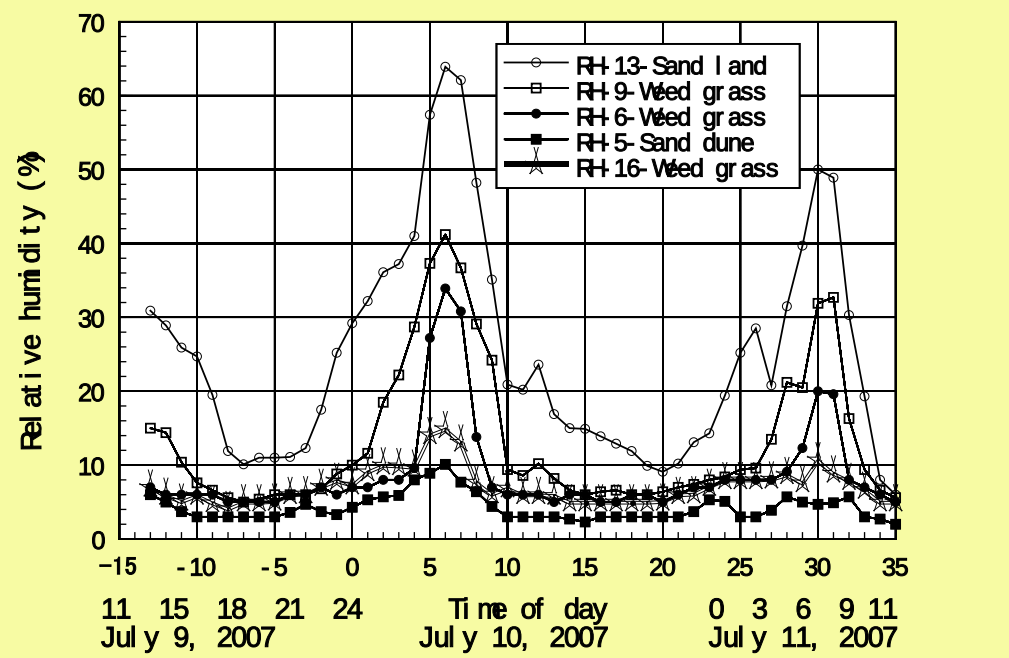
For the places with high RH in the morning on July 10, the lowest value in the night was 10.3% at No. 7, 10.4% at No. 10 and 10.7% at No. 6.

The values were high in the morning from 4:00 to 8:00. The maximum was at No. 7, a straw mat area, followed by 63.2% at No. 6, a sandy land area, 63.9% at No. 13, a sandy land area, 69.4% at No.8, a straw mat area, 72.7% at No.12, a sandy land area and 72.9% at No. 10, a sandy land area. The values in the late evening to night are similar, about 63-73%. In contrast, in dry conditions, the maximum value was 10.1% at No. 5, a sand dune area, 14.9% at No. 16, a sandy land area, 33.9% at No. 6, a straw mat area, and 41.2% at No. 9, a weed grass land.

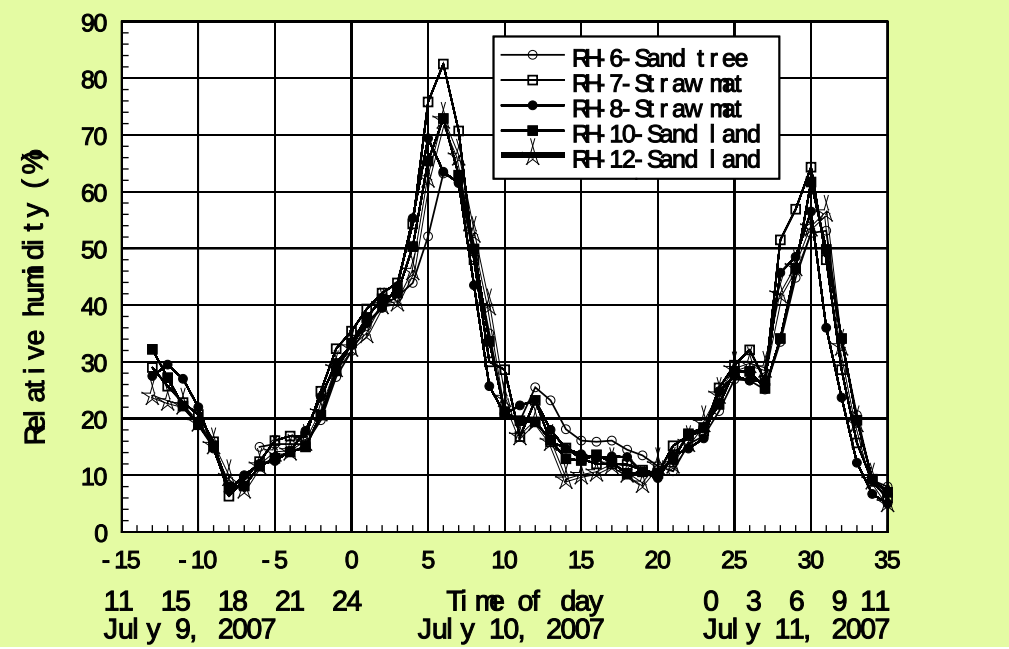
These findings indicate that the differences are not based on the species of planting trees, but on the type of vegetation, whether trees or grasses, sand, sand dune, straw mat network and so on, as the difference of the surface of pretty small scale area. Because the vegetation density of the planted tree is very low, the leaf density is also lower.

We need to develop a technique to increase the rates of root taking by planting, even under non-irrigated conditions. In addition, we must cultivate a high density condition of leaves and stems even in the arid land in China.

We were able to apply a non-irrigated planting system in Ningxia, China, which we feel was an important achievement.



(A)



(B)

Figure 2(A), 2(B). Variations of relative humidity at Daquan, Lingwu, Ningxia, China, from 11:00 July 9 to 11:00 July 11, 2007.

No. 5: RH-5-Sand dune, No. 6: RH-6-Straw mat and RH-6-Sand tree, No. 7: RH-7-Straw mat, No. 8: RH-8-Straw mat, No. 9: RH-9-Weed grass, No. 10: RH-10-Sand land, No. 12: RH-12-Sand land, No. 13: RH-13-Sand land, No. 16: RH-16-Sand land

3.3 Comparison of climate and planting trees

The observation points are No. 5, 6, 9, 10, and 11.

Maximum and minimum air temperatures and minimum relative humidity (RH) at the observation plot are shown in Table 1. The highest of maximum air temperature in the data of 5 observation plots in almost a year was 45.9℃ at No. 10 in the sandy area in the observation plot. The second-highest was 42.8℃ at No. 11 in the tree plot of *Hedysrum scoparium* and sandy area. The third was 42.5℃ at No. 5 in a sand dune area of the control plot. The lowest of maximum air temperature was 39.8℃ at No. 6 in a straw mat network plot. The second-lowest was 40.7℃ at No. 9 in weed grass land.

These values in the area covered by grass and plant straw are low compared to the values in the desert sandy area. The vegetation is important for reason based on environment improvement by the natural and artificial planting vegetation, but not so effect on the environment by the reason of small amount of artificial planting.

On the other hand, the lowest of minimum air temperature in 5 data was -20.5℃ at No. 6 in a straw mat network, the second-lowest was -20.4℃ at No. 10 in a sandy area, the third was -19.9℃ at No. 11 in a sandy area and the fourth was -19.4℃ at No. 9, and the highest of these minimum temperatures was -18.1℃ at No. 5 in a sand dune in the control plot. In winter, the surface temperature of dry plant matter of straw was decreased by radiation cooling.

There was a little low level area where the wind decreased in the depression, so the straw mat plot was cooled down. Sand dune areas are not flat, so the wind blows on the slope and the air temperature does not drop as much. The air temperature in the dune area was higher than the value recorded in the dry vegetated area. This is an important result and an understandable physical aspect.

The maximum RH was 100% for all plots. The minimum RH for the year was 2% at No. 10 in a sandy plot and No. 11 in a dry tree area, and the RH was 3% at No. 5 and 4% at No. 6 in a straw mat plot and No. 9 in a grass area plot. The minimum RH in grass and dry vegetated areas is also high by the reason based on sensitive energy by the transpiration. Another factor affecting RH is the amount of wind in a given area.

Table 1. Maximum and minimum air temperatures and minimum relative humidity (RH) at the observation plot. Maximum RH is 100% for all plots.

ME	TPP	No. 5	No. 6	No. 9	No.10	No.11
Max. air temp. (℃)		42.5	39.8	40.7	45.9	42.8
Min. air temp. (℃)		-18.1	-20.5	-19.4	-20.4	-19.9
Min. RH (%)		3	4	4	2	2

ME: Meteorological elements, TPP: No. of planting tree plot, RH: relative humidity.

4. CONCLUSION

The main results recognized by the observation are as follows:

(1) After investigating the effect on the difference of surface layer based on the difference of trees of planting area, the variations of air temperature and relative humidity comprising a microclimate which affected surface vegetation of an experiment tree-planting area were obtained.

(2) The meteorological difference was found in the difference of surface vegetation, but it was not so clearly found in the difference of planting trees.

(3) Differences in vertical profiles of wind speed, air temperature, relative humidity and surface soil temperature are based on the variety and density of plant vegetation and micrometeorological elements are affected by the tree form and leaf distribution of the covering vegetation.

(4) A non-irrigated planting system can be applied as an important achievement in an arid land in Ningxia, China.

REFERENCES

(1) Huang, S. 2008: The result of actual proof experiment of aforestation in China, Report on the Recovery of Vegetation and Protection from Yellow Sand by Planting, International Greening Promoting Center, 31-40.

(2) Maki, T. 2005: Report on the Recovery of Vegetation and Protection from Yellow Sand by Planting, International Greening Promoting Center, 48-57.

(3) Maki, T. 2006: Report on the Recovery of Vegetation and Protection from Yellow Sand by Planting, International Greening Promoting Center, 97-111.

(4) Maki, T. 2007: Report on the Recovery of Vegetation and Protection from Yellow Sand by Planting, International Greening Promoting Center, 67-74.

(5) Maki, T. 2008: Report on the Recovery of Vegetation and Protection from Yellow Sand by Planting, International Greening Promoting Center, 54-64.

(6) Maki, T. 2009: Report on the Recovery of Vegetation and Protection from Yellow Sand by Planting, International Greening Promoting Center, 63-99.