5.4 FIELD EXPERIMENT ON THE OASIS EFFECT OF URBAN AREAS USING POTTED PLANTS

Aya Hagishima [1]*, Ken-ichi Narita [2], and Jun Tanimoto [1]
[1] Kyushu University, Fukuoka, Japan, [2] Nippon Institute of Technology, Saitama, Japan

1. INTRODUCTION

The flux of urban areas is commonly estimated based on the land cover ratio and the predicted flux of each type of land usage. However, Moriwaki and Kanda (2004) pointed out that the latent heat flux observed in urban areas is larger than that predicted by the usual inventory method. In general, both the density and fetch of vegetation in urban green spaces are much smaller than those in forests. Thus the evaporation rate of vegetation per unit area in urban areas may be larger than that of forests, as predicted based on studies of the oasis effect. Under these circumstances, we performed a field experiment using numerous pot plants in order to clarify the oasis effect in urban areas.

2. EXPERIMENTAL METHOD

2.1 *Arrangement of Pot Plants*

The experiment was performed on a concrete flat space with a depth of 50 meters and a width of 100m, located in Saitama, Japan, Lat 36°01'24''N, Lie139°42'28'.

We made three types of vegetation canopy using 202-potted camelia plants with a height of about 2 meters. The potted plants of these three groups were placed at intervals of 6m, 1m, and 0.5m, respectively, as shown in Figure 1 and Figure 2. The three groups, hereafter 'isolated plants', 'sparse canopy', and 'dense canopy', are placed at a distance more than fifteen meters apart in order to prevent mutual interference. We selected the 55 potted plants for measurement of the daily evaporation rate.

2.2 *Measurement Method of Evaporation*

The weights of the 55 potted plants were measured once a day after sunset in clear weather. The daily evaporation rates of the potted plants were estimated based the reduction of their weights for two continuous days. At the start of all measurements of the evaporation rate, water was slowly supplied to the potted plants to establish a water content ratio of 97% in order to exclude the effect of water defect stress. The soil surfaces of the plants' pots were covered with a plastic bag in order to intercept the evaporation from the soil.

If the positions of the potted plants were fixed throughout the measurement period, it was expected that the growing processes of each plant would vary in terms of their position because of the differences of solar and wind conditions. Such a tendency would cause difficulty regarding the effects of both the density and fetch of the vegetation canopy during evaporation. Therefore, we changed the positions of the 55 potted plants at every measurement based on random numbers.

The period of experimentation was from October 2nd to November 7th, 2003. The data sets for twenty-eight days were obtained. The global solar radiation, air temperature, humidity, and wind velocity were measured continuously at the experimental site.

3. EXPERIMENTAL RESULTS

3.1 *Primary Difference of Evaporation Rate of Pot Plants*

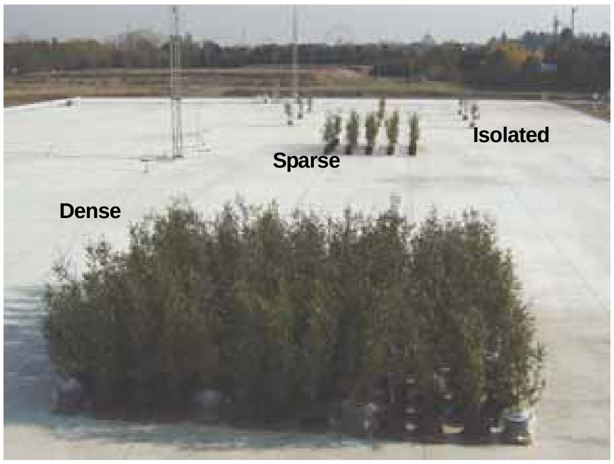
In order to estimate the primary differences of each potted plant, the daily evaporation rate of the 55 potted plants arranged equally at intervals of 3.6-meters were observed additionally in October for four days, hereafter referred to as run-S1, run-S2, run-S3, and run-S4. We compared the evaporation rate of run-S3 of all the 55 potted plants and those of the other three runs, as shown in Figure 3. Although the plots scatter widely, the relation of evaporation rates of two different days can be recognized to be positive. This implies that the primary difference of the potted plants' evaporation rate tends to be linear under various meteorological conditions. Hence, we used the normalized evaporation rate, which is defined as the ratio of evaporation rate to that of run-S3, for analysis.

**Corresponding author address*: Aya Hagishima, Interdisciplinary Graduate School of Engineering Sciences, Kyushu-University, 6-1 Kasuga-shi, 816-8580 Japan;
e-mail: aya@cm.kyushu-u.ac.jp

3.2 *Effect of density and fetch of vegetation*

In order to consider the effect of the fetch and density of vegetation separately, 'dense canopy' was divided three groups, hereafter 'periphery', 'middle', and 'core', as shown in Figure 4. In addition, the 'periphery' of 'dense canopy' is classified by direction, hereafter 'south' and 'north'.

Figure 5 shows the relationship between the amount of solar radiation and the normalized evaporation rate of isolated plants, sparse canopy, and the core of the dense canopy. Under the condition of a small amount of solar radiation, the effect of vegetation density on evaporation rate is not clear. Contrarily, under the condition of large solar radiation, the considerable dispersion of plots can be



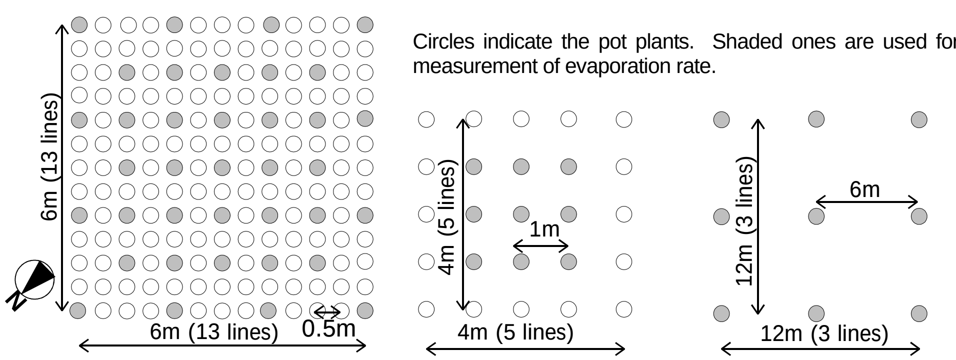
(a) Whole view of the experimental site

(b) potted plant, which has relatively large leaf area

(c) Sparse canopy

(d) Isolated plants

Fig.1 Photos of experimental site and potted plants



(a) Dense canopy (4 pots /m^2) (b) Sparse canopy (1 pots /m^2) (c) Isolated plants

Fig.2 Arrangement of potted plants

recognized. And some data of 'isolated plants' and 'sparse canopy' show notably large values. The approximate straight lines of each group indicate that the evaporation rate of 'isolated plants' is the largest and that of the 'dense-core' is the smallest. Such a tendency is more remarkable when the solar radiation is large.

Next, Figure 6 shows the average and standard deviations of the normalized evaporation rate throughout the experimental period. The evaporation rate increases with the decrease of the vegetation density. The averaged normalized evaporation rate of 'Isolated plants' is about 60% larger than that of the 'core' of 'dense canopy'. The effect of the fetch of vegetation is also remarkable. The evaporation rate of the 'periphery' of the 'dense canopy' is 1.3 times as large as that of the 'core'. When the two directions of the 'periphery' are compared, the evaporation rate of the 'south' is larger than that of the 'north' due to the differences of solar condition.

4. CONCLUSION

A field experiment using numerous potted plants was performed in order to clarify the oasis effect in urban areas. The measurement results for 28 days indicate that the evaporation rate of an isolated plant is one-and-a-half times larger than that of the center of the dense canopy.

Acknowledgments

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References

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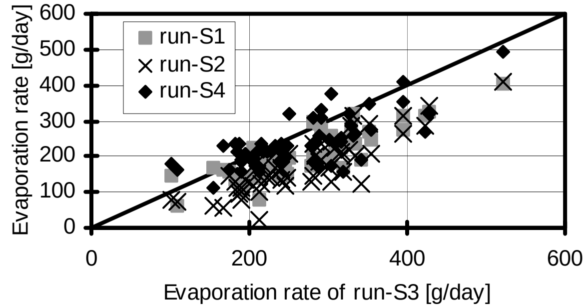

Fig.3 Relationship between the of evaporation rate of run-S3 and those of run-S1, S2, and S4

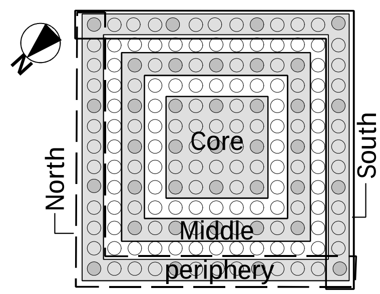

Fig.4 Grouping of the potted plants

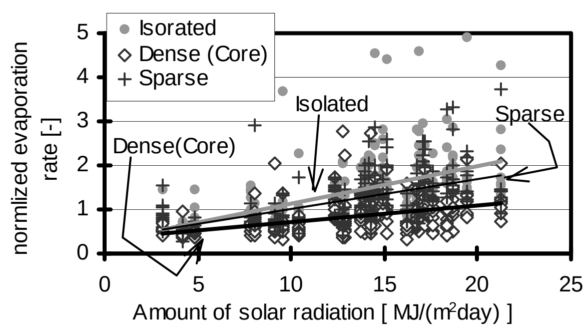

Fig.5 Relationship between the amounts of solar radiation and the evaporation rate of different vegetation densities

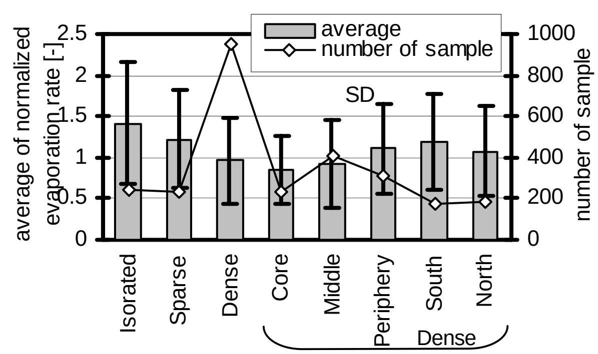

Fig.6 Average of normalized evaporation ratio