E4 -WHOLE YEAR COMPARISON OF CONTROLLING TEMPERATURE AND WATER BALANCE AT ROOFTOP GARDENS WITH HYDROPHYTE

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Abstract

This study clarified an environmental performance of rooftop gardens that used the hygrophyte by the field experiment. Water consumption and the temperature etc. of each part were measured in the expert year, and the results were compared in two divisions of the hygrophyte and the grass. Moreover, the examination district with two circuit systems was installed, and changes in the water quality by the rainwater use were compared.

As for the vertical temperature distribution of the hygrophyte division and grass division, the hygrophyte division was from 2°C to 3°C low, and the temperature controlling effect were confirmed in summer.

The amounts of sprinkling water except the day with precipitation and the availabilities of the water were compared in the hygrophyte division and the grass division. A large difference was seen in the availability of water though a large difference was not seen in the amount of sprinkling water. Water can be used for the hygrophyte division by the water level control without uselessness so that there is a ponding action though a part of water that passed an artificial soil after water is sprinkled flows out in the grass division.

Moreover, when the amount of evapotranspiration in a fine day in summer were compared, it was understood for the hygrophyte division to increase to about 1.5 times that of the grass division, and to be able to expect minute weather easing and the flood controlling effect.

Keywords

Rooftop Gardens; Hydrophyte; Field Experiment; Water Circuit Systems.

1 Introduction

Recently, a lot of rooftop gardening has been introduced for the measures of heat island phenomenon that is one of the city environmental problems and the improvement of the spectacle. Authors have been researching concerning rooftop gardening over many years 1)-3). Especially, it works about rooftop gardening that makes the best use of the characteristic of the hygrophyte in recent years. The plant with abundant amount of evapotranspirations is preferable to control the temperature rise efficiently.

Then, the previous year's research[4)] is continued, and an environmental performance of rooftop gardening that uses the hygrophyte is clarified by the field experiment in the present study. Water consumption and the temperature etc. of each part are measured, and it compares it by the grass with the hygrophyte in the whole year. Moreover, the examination districts with two circuit system are newly installed, and the water quality etc. when rainwater is used are examined by comparing two circuit systems.

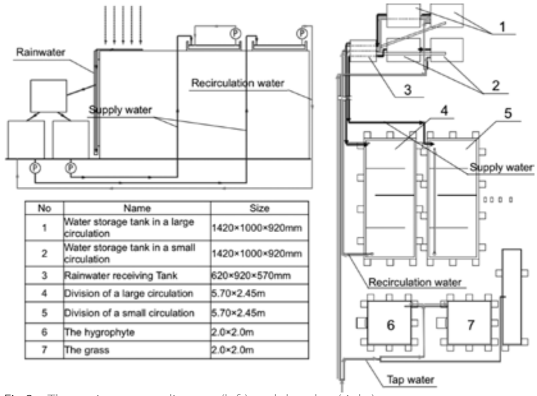
2 Field experiment

This experiment used division (2.0m×2.0m) of the hygrophyte (*Carex thunbergii Steud.*) and grass (*Zoysia matrella*) to compare the temperature and the water balance that had been set up in fiscal year 2009 at the experiment building rooftop in the Kawagoe campus of Toyo University. Fiscal year 2010, the temperature and the water balance, etc. were compared in division (5.70m×2.45m) to compare the water circuit systems in addition to these divisions. These divisions are the small circuit system that circulates water only in the examination district and the large circuit system that circulates water including the water storage tank.

Moreover, the photograph in the entire examination district is shown in Figure-1. The photograph in the water storage tank and the rainwater receiving tank are shown in Figure-2. The entire system diagram and the plan are shown in Figure-3. About the temperature and the water revenue and expenditure comparison examination district, the cross section of the hygrophyte division is shown in Figure-4 and the cross section of grass division is shown in Figure-5. The cross section of the examination districts with two circuit system is shown in Figure-6.

Fig. 1 – The entire examination district

Fig. 2 – Water Storage Tank (left) and Rainwater receiving tank (right)



No	Name	Size
1	Water storage tank in a large circulation	1420×1000×920mm
2	Water storage tank in a small circulation	1420×1000×920mm
3	Rainwater receiving Tank	620×920×570mm
4	Division of a large circulation	5.70×2.45m
5	Division of a small circulation	5.70×2.45m
6	The hygrophyte	2.0×2.0m
7	The grass	2.0×2.0m

Fig.3 – The entire system diagram (left) and the plan (right)

Table-1 Outline of measurement

Green roof system	Measurement item	A period of measuring	Measuring equipment	Measuring interval
Temperature and water Balance	Temperatures (11 points)	2009/12/1-2010/11/30	Resistance temperature sensor, data logger	10min.
	Water level in the hygrophyte division and a measure		Water level indicator , data logger	
	Sprinkle water consumpiton		Water consumption meter, data logger	1d.
Two circuit systems	Temperatures (11 points)	2010/5/1–2010/12/31	Resistance temperature sensor, data logger	10min.
	Water level in the the rainwater receiving tank	2010/7/24–2010/11/30	Date logger	
	Circulating water consumption		Date logger	
	Water quality	2010/8/18～2010/11/29	Water quality weighing device	Semimonthly
Both system	Weather data	2009/12/1–2010/12/31	Automatic wather station	10min.

Table-2 Condition of sprinkling water

	Hygrophyte	Grass
Sprinkle water time	03:00	04:00
Method	If the water level of the hygrophyte division is under 3cm, it is sprinkled water to 4cm. (Water volume is about from 15 to 55L.)	20min (Water volume is about 21L.)

No.	Measuring point
1	Under water shielding seat
2	In the water
3	On the substrate
4	In the community
5	On the community

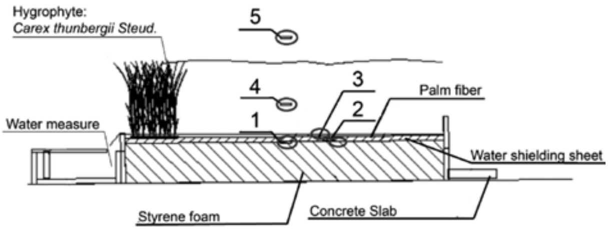


Fig. 4 – Cross section of hygrophyte division

No.	Measuring point
1	Under water shielding seat
2	5cm underground
3	On the substrate
4	In the community
5	On the community

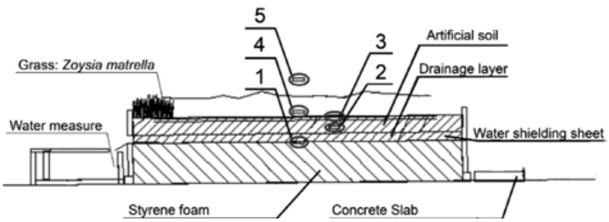


Fig. 5 – Cross section of grass division

No.	Measuring point
1	100mm height in a community
2	250mm height in a community
3	500mm height in a community
4	1000mm height in a community

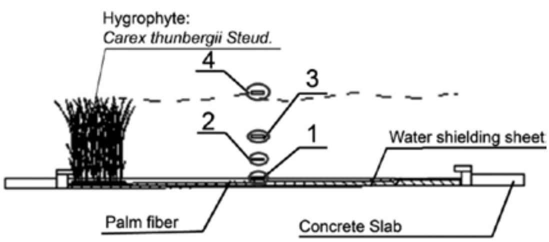


Fig. 6 – Cross section of the examination districts with two circuit system

3. Result and analysis

3.1 Temperature controlling effect

The average temperature of each measurement part was calculated at the temperature and water balance comparison district, and the circulation comparison district. The result in August is shown and the result in Figure-7 and December is shown in Figure-8. The day that the highest temperature was 30ºC or more and the amount of solar radiation of fine day was 20MJ/m^2 or more was targeted in August. The day that the amount of solar radiation of fine day was 10MJ/m^2 or more was targeted in December.

Some differences of the temperature of the hygrophyte division are smaller than that of grass division in August (Figure-7). It is thought that the temperature lowered by the use of water and insolation screening effect by high grass height in the hygrophyte district. The average temperature became from all 5 to 10ºC in December, and the difference was not seen (Figure 8). The temperature had fallen for the influence by sprinkling water in case of the sealing seat in grass division. Moreover, the temperature on the colony has little difference in the hygrophyte division and grass division.

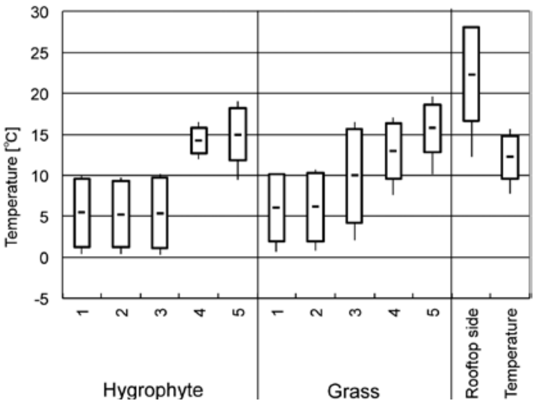


Fig. 7 – Average temperature of each measurement part at the temperature and water balance comparison district, and the circulation comparison district (August)

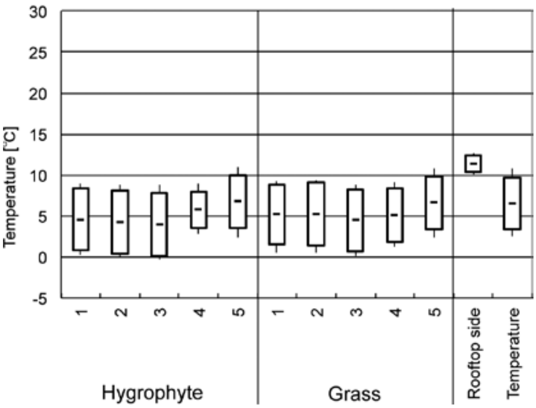


Fig. 8 – Average temperature of each measurement part at the temperature and water balance comparison district, and the circulation comparison district (December)

3.2 Water balance

The amount of sprinkling water and water use rate in the hygrophyte division and grass division are shown in Figure-9. Data excludes the day of rain. It was not possible to record in February and March.

As for the amount of sprinkling water, the hygrophyte division is the same or few as the grass division excluding October. Moreover, the hygrophyte division passes for one year, there is no amount of flow, and can use all the water sprinkled. Therefore, the hygrophyte division can be a little water consumption and use water without uselessness.

The day amount of the evapotranspiration in August and December is shown in Figure-10. The day when the highest temperature was 30°C or more and the day multiplication amount of solar radiation was 15MJ/m^2 or more was targeted in August. The day when sprinkling water of grass division had been done was targeted in December. The amount of evapotranspiration of the hygrophyte division is about 1.5 times as more as that of grass division in August. There is the day amount of evapotranspiration of about 1.0MJ/m2 in the hygrophyte division though there is hardly the day amount of evapotranspiration in grass division in December.

3.3 Water quality comparison in circuit system

Water in the rainwater storage tank of both circuit systems and rainwater, the total nitrogen (T-N) and the total phosphorus (T-P) are shown in Figure-11.

Because the adjustment doesn't go well, and rain water from the gutter was hardly distributed to the water storage tank of the small circuit system, the value of the small circuit system is equal to tap water that is make-up water in both T-N and T-P. Therefore, the value of the small circuit system has lowered to all phosphorus.

On the other hand, it is thought that the value of T-P rose because a part of the hygrophyte withers in July and phosphorus eluted from the plant body in the large circulation. As for the T-N, it is understood that the density doesn't increase greatly even if they are made to circulate as a result.

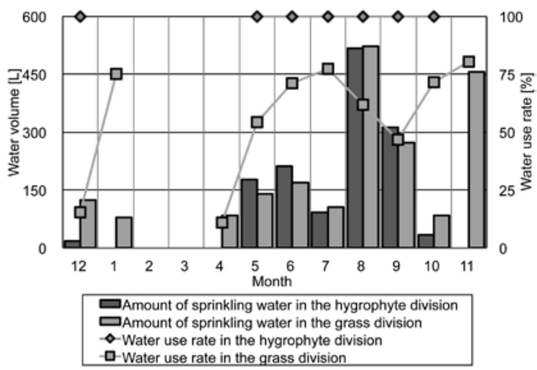


Fig. 9 – Amount of sprinkling water and water use rate (each month)

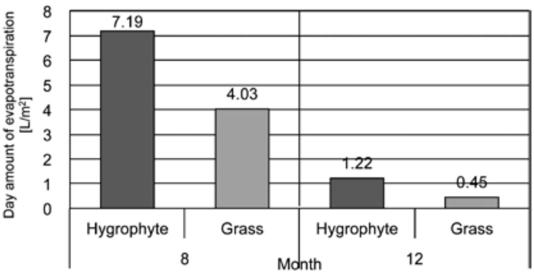


Fig. 10 – Day amount of evapotranspiration of each division in August and December (average)

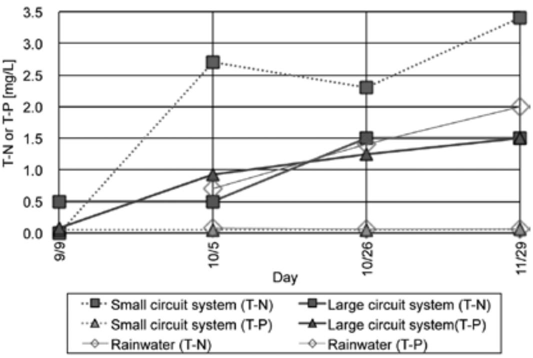


Fig. 11 – Changing of T-N and T-P with circuit system

4 Conclusions

In the present study, the temperature controlling effect and the water balance on the rooftop gardening that used the hygrophyte were measured throughout the year, and each performance of each division in summer and winter was clarified. The research on the influence that the difference of the circuit system gives to the water quality and the water balance in the system is advanced continuously in the future.

5 References

1. H. Kose (2004). Growth Situation and Temperature Change of the Rooftop Gardens by the Kind of Soil and Plant, Summaries of 31st Environment System Symposium, Japan Societies of Civil Engineers (pp.393-397)
2. M. Tsuji et al. (2007): Evapotranspiration, temperature rise control effect by Carex thunbergii Steud. adopteded in rooftop greening, Journal of Japanese Society of Revegetation Technology (33(2), pp.359-368)
3. M. Tsuji et al. (2008): Controlling rising temperatures using Carex thunbergii Steud. for rooftop greening, Journal of Japanese Society of Revegetation Technology (34(2), pp.375-383)
4. H. Kose and M. Tsuji (2010). Controlling Effect of Temperature Rise and Water Balance at Rooftop Gardens with Hydrophyte, Summaries of technical papers of Annual Meeting Architectural Institute of Japan (D-1, 40302, pp.629-630).

6 Acknowledgement

The research subsidy of the Obayashi Foundation was received and the present study was executed.
This study is cooperative research with KOIWAI FARM, Ltd. It tenders an apology to Tadashi Tarusawa and Hayafumi Ueda of this company Tokyo Landscaping Branch who is the research cooperator.
The cooperation of Tatsuo Nagashima and Yosuke Nakamura, Atsuo Otsuki that were the Toyo University graduate was got, when this study was advanced. The gratitude is expressed.

7 Presentation of Author

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