Field Application of Self-Watering System in Genkai Town

Kyushu University Student Member Qiang Liu
Kyushu University Member Noriyuki Yasufuku, Kiyoshi Omine, Hazarika Hemanta

INTRODUCTION

The soil layer often provides a medium to plant for its requirement of rooting, water and nutrient. The water flow has effect on physical property, such as consistence, strength of aggregates, aeration and temperature of soil, which is relevant to the growth condition of plant. The most direct effect of the water condition of soil is that it influences the growth of plant. The root of plant can absorb the amount of water to fulfill its need for transpiration and the amount of solute for its mineral nutrient. The transpiration water disappears in atmosphere as vapor condition. Finally, a water flow moves through soil towards to the roots.

In arid or semiarid area, which characterized by severe lack of available water, water is one of the main limitations to the growth of the plants. Frequently, the water resource is too deep to be used by the plants in these areas. In order to provide water sustainably to the plants, the self-watering system and the design methodology have been proposed. The self-watering system, which is designed to collect and store most kinds of water, comprised with the original sandy ground is much efficient to support surface vegetation. The system is designed by installing soil structures into original sandy ground. Finer soils or artificial materials can be used as the materials of the soil structures. The system can continually raise the ground water to a certain depth in the sandy ground using the capillary force. Moreover, it can minimize the evaporation from the system, which provides the potential to minimize salinization. The self-watering system works under the condition of no extra energy input. To design the system practically, information like soil water retention curve, hydraulic conductivity and other information such as planting density and weather conditions are needed.

In this paper, series of field tests were conducted in order to verify the functions of the system and provide the data to be used in generalization of the system. The setup of the field tests and simulated results were shown.

SELF-WATERING SYSTEM

Fig. 1 shows the conceptual diagram of the self-watering system located in sandy ground. As shown in the figure, two types of the self-watering system are proposed. The left side of the figure is the system in 'T' type. The right side of the figure is the system in suspended type. Both the two types of the self-watering system are made from installing fine material layer into sandy ground.

The 'T' type system consists of plate part and pillar part. The plate part is horizontally buried in sandy ground. The main function of plate part is to store water. Therefore, the design of this part should be large enough to reach the required storage quantity. The pillar part is vertically inserted down to the ground water level in sandy ground. The main function of pillar part is to absorb water by capillary force. Therefore, the design of this part should be large enough to assure the rate of supply to the plate part. For the self-watering system in suspended type, it contains only a plate part. The function of the plate concludes both functions of plate part and pillar part of the 'T' type system. The design target of the system is to setup an equivalent condition between the storage capacity of water and rate of usage. In order to design the system properly, the available storage capacity of the system and the rate of water supply should be determined.

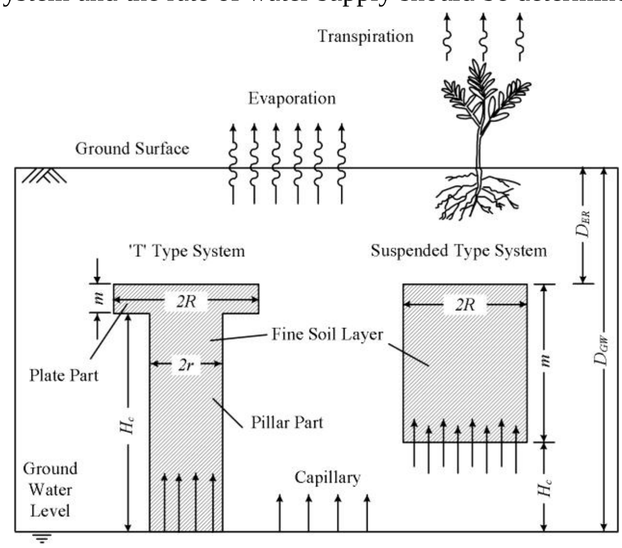

Figure 1 Image of the self-watering system

TESTS AND RESULTS

The field tests were conducted in the greenhouse in Genkai town. The area of the field is about 66 m^2 (11 × 6 m).The depth is about 3 m. At the bottom of the field, there is a gravel layer and the thickness is about 50 cm. above the gravel layer is sand layer and the thickness is about 250 cm. The sand used in this study is named k-7 soil the grain size distribution is shown in Fig. 2. The k-7 soil is used to simulate the sandy soil in the arid area since the grain size distribution curve is similar to the natural sand. The other kind of soil used in the study is named k-8 soil. Both of them are commercially available. The k-8 soil is used to as one kind of finer materials. The ground water level is maintained at -240 cm from ground surface. Totally, 12 cases of self-watering system are conducted. These can be separated into four groups. Group A, B and C are 'T' type system. Group D is suspended type system. The design variable is shown in Table. 1. Fig. 3 shows the bird view of the setup of the tests.

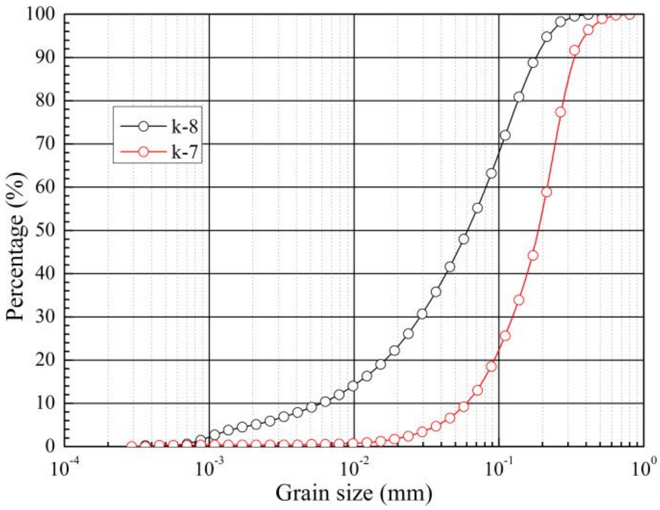

Figure 2 Grain sizes of the k-7 and k-8 soils

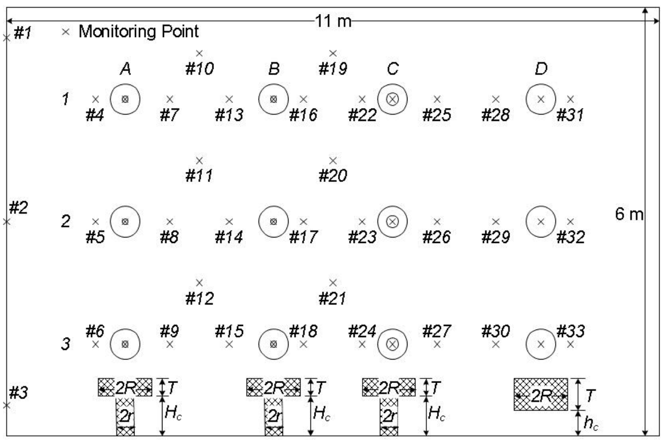

Figure 3 Bird view of the setup of the field tests

The setup of numerical model follows the experiment work described as follows; the upper boundary is atmospheric condition. The lower boundary was assigned to condition of constant saturated water content. The FEM column was discretized uniformly. A number of observation points were located at different elevations. The vG model with parameter restriction was adopted as hydraulic model when conducting numerical simulation. The hydraulic parameters were obtained from soil water retention test and permeability test. Figure 4 shows the simulated results using numerical method.

Table. 1 Design Variables of tests

Group	Case	r (cm)	R (cm)	T (cm)	H_c (cm)
A	1	5	25	80	140
	2	5	25	120	100
	3	5	25	160	60
B	1	5	25	70	140
	2	5	25	60	140
	3	5	25	90	140
C	1	10	25	80	140
	2	10	25	120	100
	3	10	25	160	60
D	1	—	25	140	80
	2	—	25	160	60
	3	—	25	20	20

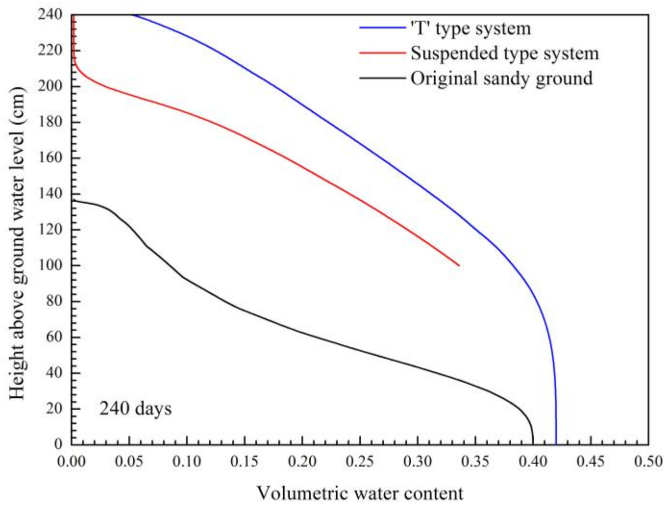

Figure 4 Simulation results of the system

CONCLUSIONS

It is easily observed that both the two types of the self-watering system can fulfill the requirement of designed functions.

ACKNOWLEDGEMENT

This research was supported in part by joint project between Kyushu University, Fukuoka and Genkai town, Saga prefecture, on cultivation of medical plant in arid ground, and Grant-in Aid for scientific research (A) No. 22246064, from Japan Society for the Promotion of Science (JSPS). The authors acknowledge the supports.

REFERENCES

Q. Liu. Development and Evaluation of Self-Watering System in Unsaturated Arid Ground, PhD's dissertation, 2011.