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A STUDY ON THE IMPROVEMENT OF GROUNDWATER RECHARGING FOR SUSTAINABLE FACILITY HORTICULTURE, KOREA

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ABSTRACT In this study, the degree of influence of facility horticultural activities on groundwater charging was analyzed. Furthermore, we looked for ways to improve it. Glass greenhouse, on 1ha of Gimje area, was penetrated by 15.8 mm of precipitation, which is 1.15% of the 997.6 mm over a year. Similarly, the Gumi Glass Greenhouse was 3.7 mm underground water cultivation compared to 1070.3 mm of rainfall, the Buyeo Vinyl Greenhouse was 24.8 mm, and the Jinju Vinyl Greenhouse was 30.9 mm penetrated. Improved packaging materials were applied with trench-type gravel packaging and general wetlands, widely distributed as LID facilities. At 1071.82 mm of rainfall, wetlands can be calculated by 346.37 mm of penetration and gravel packaging by 516.61 mm of penetration. Wetlands and gravel packing have a very high amount of groundwater incubation. In the future, this space needs to be sufficiently increased when developing facility horticulture. Through these studies, we aim to preserve and improve the value of various ecosystem services in the agricultural ecosystem. This study was supported by the 2021 RDA Fellowship Program (Project number PJ014190) of the National Institute of Agricultural Sciences, Rural Development Administration, Republic of Korea.

Keywords: Agricultural landscape, Gee lysimeter, Groundwater recharge

INTRODUCTION The proportion of facility horticulture in Korea is about 40 percent or more. Moreover, the facility horticulture area ranks third after China and Spain. Therefore, facility horticulture contributes significantly to Korean agriculture (Lee, 1996; Ko et al., 2013; MAFRA, 2014a, 2014b). Spain's Iberian Peninsula region, similar to Korea's facility horticulture development, is also Europe's largest vegetable producer. The region has had a positive function that significantly improves the local economy and living standards (Christina Quintas-Soriano et al., 2016; Aznar-Sanchez et al., 2011; Aguilar et al., 2015; Mota et al., 1996). However, the creation of horticulture in the Iberian Peninsula region resulted in lower groundwater levels and higher salt concentrations (Consejeria de

Agricultura y Medio Ambiente, 1991; Martinez-Fernandez and Esteve-Selma, 2002; Pulido-Boschet al., 2002; Sanche et al., 2002).

Korea traditionally produces rice paddies, and rice is a staple food. So, in the 1970s, rice paddies were much more abundant than they are today. The gardeners used this rice paddy to make vinyl greenhouses or glass greenhouses. The paddy field is evaluated as a wetland due to its excellent groundwater cultivation (Ramsar, 2014; Kong et al., 2014). However, these greenhouses are covered with non-potable cladding, lack space for underground water needed for gardening. Groundwater should be replenished continuously for sustainable facility gardening.

Therefore, in this study, the degree of influence of facility gardening activities on groundwater charging was analyzed. Moreover, we looked for ways to improve it. Such research can be used to improve the groundwater sector for sustainable agriculture. It is also expected to be used as a policy material reflected in the facility horticultural complex's future development projects.

METHODS

Precipitation was measured using the EM50 Digital Data Logger of Decagon Devices to investigate the possibility of underground water cultivation, and groundwater penetration was used with the Gelysmeter (Drain Gage G3) of Decagon Company. Drain Gauge G3 fills a cylindrical barrel of constant volume with soil as the existing ground and measures water penetrated by precipitation or irrigation water through a wick collection device. Equipment that can observe penetration rates at regular time intervals (Ha et al., 2016).

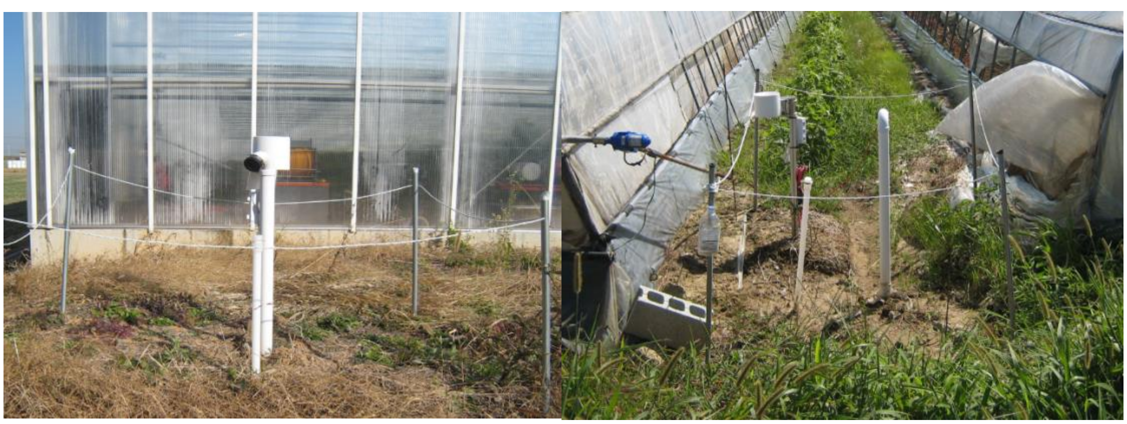


Figure 1. Picture of Drain G3 installation (left: Glass greenhouse, Right: Vinyl greenhouse).

The amount of water collected through Drain Gauge G3 is measured in real-time in barometric units, stored in the data logger (EM50), and converted into volume. In this study, Drain Gauge G3 was installed in a total of four local facility horticultural complexes, as shown in Figure 1, to compare their ability to cultivate groundwater with four previous land-use rice paddies.

It was assumed that gravel pavement and wetlands were planned spatially to enhance groundwater cultivation in the facility horticulture area. These two packaging materials have excellent functions for underground water cultivation. Therefore, groundwater cultivation experiments were conducted on these two materials.

RESULT

Measurement of groundwater content in a facility horticultural complex

According to a one-year survey from 2016 to 2017, Gimje-Glass measured 4.4 mm, while Gumi Glass measured 3.7 mm, Buyeo Vinyl 24.8 mm, and Jinju Vinyl 30.9 mm. Rainfall by region studied shows that Gimje has a very high rainfall outflow rate from 997.6 mm to 1374.3 mm in pearls (Choi et al., 2004; Lee and Han, 2013; Yun et al., 2013). The experiment was conducted in a pitcher-capable space.

Table 1. 4 study site monthly groundwater infiltration (unit: mm).

Monthly Classification	Gimje		Gumi		Buyeo		Jinju	
	Glass	Rainfall	Glass	Rainfall	Vinyl	Rainfall	Vinyl	Rainfall
1	0.0	13.4	0.0	4.7	0.4	16.0	0.5	8.1
2	0.0	52.6	0.0	30.8	0.8	28.5	1.0	37.8
3	0.2	24.1	0.2	25.1	0.3	8.8	0.4	31.4
4	0.5	57.8	0.4	56.2	0.9	78.4	1.2	94.9
5	0.4	84.3	0.3	59.4	0.8	121.6	1.0	153.9
6	0.6	95.8	0.5	29.0	0.9	49.4	1.1	113.8
7	0.8	251.8	0.7	325.4	3.2	341.1	4.0	161.0
8	0.7	35.8	0.6	114.7	4.1	33.4	5.1	74.8
9	0.5	145.4	0.4	238.5	7.7	133.7	9.7	407.5
10	0.4	152.3	0.3	155.1	4.6	120.1	5.8	170.1
11	0.2	37.5	0.2	12.0	0.1	17.1	0.1	37.0
12	0.1	46.8	0.1	19.4	0.9	63.1	1.1	84.0
Accumulated Infiltration	4.4	997.6	3.7	1070.3	24.8	1011.2	30.9	1374.3

Only about 20% of the total space available for pitchers is available. The calculation of the area's groundwater penetration was accurately calculated by substituting the measured groundwater penetration measurement (Measures) in the ratio of the permeable area per ha. Glass greenhouse based on 1ha of Gimje area was penetrated by 15.8 mm, which is 1.15% of the 997.6 mm of precipitation over a year. Similarly, the Gumi Glass Greenhouse was 3.7 mm underground water cultivation compared to 1070.3 mm of rainfall, the Buyeo Vinyl Greenhouse was 24.8 mm, and the Jinju Vinyl Greenhouse was 30.9 mm penetrated; this corresponds to a study by Christina et al. (2016), which found that greenhouse construction negatively affects ecosystem services. In addition to the groundwater cultivation analyzed in this study, the impermeable area can lead to a degradation of various ecosystem service functions, such as blocking the passage of living things and discontinuing biological forms.

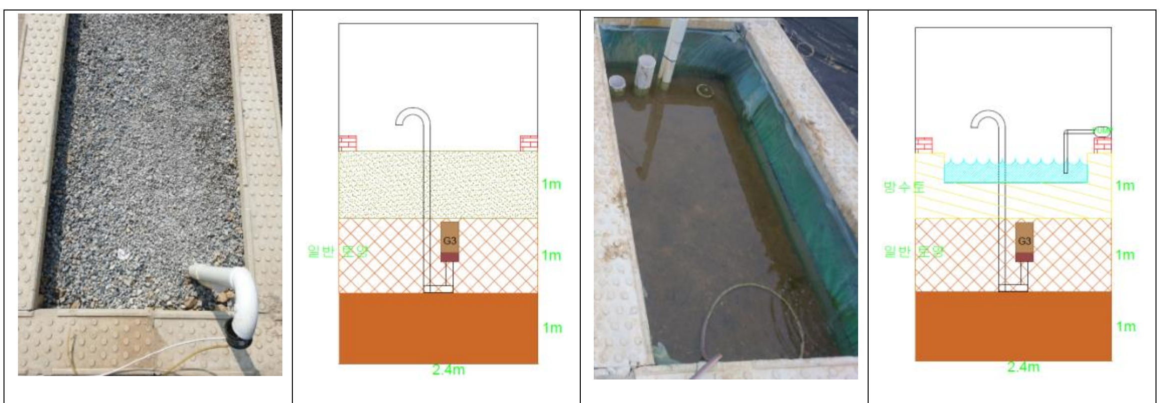
Improvement of Groundwater Cultivation in the Facility Horticultural Complex

The same method was conducted using the previously used EM50 Digital Data Logger from Decagon Devices to investigate the possibility of groundwater cultivation for improvable packaging materials. Improved packaging materials were applied with trench-type gravel packaging and general wetlands, widely distributed as LID facilities.

Based on the regression formula of penetration of wetlands and gravel packaging, the study site's average rainfall data can be calculated as 346.37 mm for wetlands and 516.61 mm for gravel packaging when the rainfall is 1071.82 mm. This data was intended to be used to present improvements in the construction of a facility horticultural complex.

Table 2. Monthly groundwater penetration (unit: mm) of packaging materials that can be improved.

Monthly Classification	Rainfall	Gravel			Wetland		
		Runoff	Infiltration	Evaporation	Runoff	Infiltration	Evaporation
1	8.09	0	3.70	4.39	0	2.59	5.5
2	37.98	0	18.18	19.8	0	14.88	23.1
3	38.68	0	18.52	20.16	0	15.07	23.61
4	88.24	0	42.53	45.71	0	28.57	59.67
5	118.67	0	57.27	61.4	0	36.86	81.81
6	119.19	0	57.52	61.67	0	37.00	82.19
7	295.89	0	143.11	152.78	0	85.13	210.76
8	165.16	0	79.79	85.37	0	49.52	115.64
9	51.16	0	24.56	26.6	0	18.47	32.69
10	74.32	0	35.79	38.53	0	24.78	49.54
11	40.46	0	19.38	21.08	0	15.55	24.91
12	34.00	0	16.25	17.75	0	13.80	20.2
Total	1071.82	0	516.61	555.21	0	346.37	725.45



Gravel | Wetland

Figure 2. Photographs of surface experiments to improve groundwater incubation (Left: Gravel, Right: Wetlands).

CONCLUSION More than 40 percent of our agricultural horticulture industry is said to have achieved the white revolution. These horticulture industries provided a great net function to improve the local economy and farm income. However, it is estimated that there are ecologically diverse threats due to the expansion of non-projection areas and disorganized space development. Among the various ecosystem service functions of the agricultural landscape, this study measured and analyzed the amount of groundwater loss used in facility horticultural farming but fell due to expanding the impermeable area. Finally, we looked at ways to improve groundwater cultivation for sustainable facility gardening.

The large loss was confirmed by looking at the research site's entire area and measuring the groundwater content. It is necessary to inject eco-friendly facilities, land-use plans, and groundwater incubation devices necessary for underground water cultivation at the complex level, not at the farm unit, from a long-term perspective. Among the LID technologies that can enhance groundwater content, wetlands and gravel packaging have a very high groundwater cultivation effect. In the future, this space needs to be sufficiently increased when developing facility horticulture.

It is hoped that this research result will be used as a policy material that can be reflected in the improvement of the groundwater field and the future development project of the facility horticultural complex for sustainable agriculture. Through these studies, the value of various ecosystem services in the agricultural ecosystem is not degraded but is intended to contribute to preservation and improvement.

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