Investigation of pear growth under foldable agrivoltaic structure

Geun Ho Gim[1], Jongsung Park[1], Tae young Kim[1], Deok Sung Kim[1], Wooram Kim, Jaewoo Nam[2] and Cheolhyun Lim[1, *]

[1] Solar Energy R&D Dept., Green Energy Institute, 177 Samhyangcheon-ro, Mokpo-si, Jeollanam-do, 58656, Republic of Korea

[2] Solarfarm Co. Ltd., 40, Yeongudanji-ro, Ochang-eup, Cheongwon-gu, Cheongju-si, Chungcheongbuk-do, 28116, Republic of Korea

* chlim@gei.re.kr

1. Introduction

Agrivoltaic is a fusion system that could share solar energy for the co-prosperity of agriculture and photovoltaic system. Based on renewable energy policy "RE3020," Republic of Korea Government aims to distribute about 48.7GW of renewable energy between 2018 and 2030, with 37GW by photovoltaics. Additionally, the situation in rural area is deteriorating year by year due to the lack of domestic farm workers, aging population and the decrease in income. Therefore, research and development on agrivoltaic system for suppling photovoltaic has began 2016, so far, a demonstration systems about 1GW has been established, and various studies has been conducted such as, development of structure, PV modules, and standard farming techniques for various crops (rice, anion, cabbage, potato, garlic, pear and grapes et. al.). Therefore, in this study, foldable structure development and pear growth analysis were conducted to develop agrivoltaic system targeted for pear.

Fig. 1: Development and construction of agrivoltaic system for pear fruit.

2. Material & Methods

2.1. Experimental overview

Field test site for development and demonstration of pear agrivoltaic system (‘18~’19) were selected as actual pear orchards in Naju-si, Jeollanam-do, Republic of Korea. The area used for this site was 210m^2, and a foldable driving unit was applied to enable folding PV modules according to pear trees cultivation characteristics. In this field test, 10kW agrivoltaic system is installed, and pear growth changes were compared by setting the field with the same number of trees as a control. When constructing the development structure, the basic construction method using the fibre-reinforced plastic (FRP) case was used to minimize the environmental impact to land and fruit growth. The pear growth analysis was conducted for a total of 12 items such as quantity, sugar content and weight.

2.2. Agrivoltaics PV module

The PV modules for agrivoltaic system used in this study was composed of 4 rows and 9 columns (4x9) of crystalline silicon solar cells (36 cells in total), the shading rate by the PV modules was set up to 30%, and the shading rate was variable from 0 to 30% depending on the folding operation.

3. Results

3.1. Development of folding drive structure

The PV module supporting structure was 14x 14m in width and height, and the height of the structure was set to 4 m in consideration of growth characteristics of the pear tree and farming radius. In addition, the structure was designed to withstand the wind speed >30m/s and snow load and seismic loads.

Fig. 2: Foldable agrivoltaic structure design and folding module system driven.

3.2. Pear growth effect

In the winter to spring period, the pear flowering was relatively improved compared to the control group, mainly due to blocking the frost and cold by the upper PV modules. Also, in the case of the pear flower under PV modules, the flowering period increased by about 5 days compared the control group, and accordingly, the pear fruit had a positive effect on increasing the vertex length by about 32%. Especially, the fall rate of pear fruits decreased by about 38% compared to the control group when landing on the 13th typhoon “Lingling” in 2019.

3.2 Pear quantity and quality effect

As a result of examining the quantity and quality of pear fruit under the PV modules during 2018, when harvested at the same time, the quantity compared to the control group (4.4ton) was about 4.1ton/10a (6.7% decreased). Moreover, individual weights and sugar content of cultivated pear under the PV modules were also reduced by about 4.5% and 1.3°Bx compared to the control group. Although the amount of solar radiation reaching the pear fruits under the agrivoltaic was adjusted by using the foldable driving system of the PV module, the quantity and quality were reduced due to the lack of the solar radiation reaching the pear fruit compared to the control. However, as a result of maturing the growth period of the agrivoltaic pear fruit for about 2 weeks, the individual weight increased by about 8.5% compared to the control, and the sugar content (10.6°Bx) rose to close to the control (11.0°Bx).

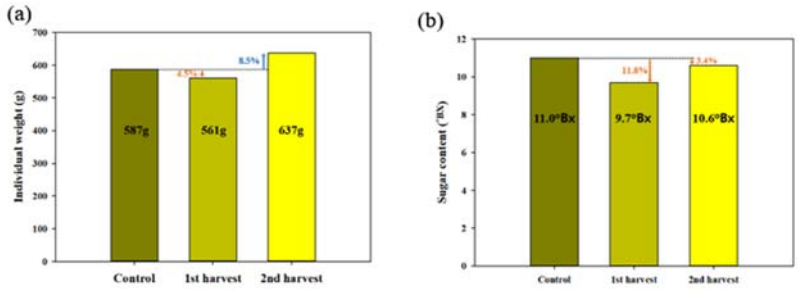

Fig. 3: Analysis of (a) weight and (b) sugar content of pear fruit applied under foldable agrivoltaic system.

4. Acknowledgment

This work was supported by the Korea Institute of Energy Technology Evaluation and Planning(KETEP) and the Ministry of Trade, Industry & Energy (MOTIE) of the Republic of Korea (No. 20173010013390)

References

[1] T. Kim, Assessment of power peneration and agricultural environmental changes according to string composition in the agrophotovoltaic module, KIEEP, (2020).