Evaluation of climate change on the rice productivity in South Korea using crop growth simulation model

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ABSTRACT

Evaluation of climate change on the rice productivity was conducted using crop growth simulation model, where Odae, Hwaseong, Ilpum were used as a representative cultivar of early, medium, and medium-late rice maturity type, respectively, and climate change scenario 'A1B' was applied to weather data for future climate change at 57sites. When cropping season was fixed, rice yield decreased by 4~35% as climate change which was caused by poor filled grain ratio with high temperature and low irradiation during grain-filling. When cropping season was changed, rice yield decreased by only 0~5% as climate change which was caused poor filled grain ratio with low irradiation during grain-filling period. However, this irradiation decline was less than when cropping season was fixed. Therefore, we need to develop rice cultivars resistant to low irradiation which can maintain high filled grain ratio under poor irradiation condition, and late maturity rice cultivars whose growing period is longer than the present medium-late maturity type.

Key words : Climate change, Rice, Crop growth simulation model, Cropping season, Temperature, Irradiation

I. INTRODUCTION

Temperature rising in future climate change is accompanied with CO_2 concentration increase, where one has negative effect, the other has positive effect on the rice production, but CO_2 concentration only or interaction effect with temperature on the rice was not clearly investigated (Kim et al., 2003). The use of crop growth simulation model is the most economical strategy for evaluating climate change on the rice if there is credibility in their results.

II. MATERIALS AND METHODS

2.1. Crop growth simulation model

Evaluation of climate change on the rice productivity was conducted using rice growth simulation model 'ORYZA2000' which was developed by IRRI and Wageningen university in 2001 (Bouman et al. 2011).

2.2. Cultivar

Odae, Hwaseong, Ilpum were used as a representative cultivar of early, medium, and medium-late rice maturity type, respectively.

2.3. Climate change condition

Climate change scenario 'A1B' was applied to weather data for future climate change at 57sites. ORYZA2000 requires daily irradiation, minimum and maximum temperature and precipitation as minimum data set of weather data. All weather data were arranged to 30 year average values for 1971~2000 as the present, 2011~2040, 2041~2070, and 2071~2100 as the future climate condition.

<<<Table. 1>>

III. RESULTS

3.1. Simulation using original ORYZA2000 and its modification

In the simulation results using original ORYZA2000, the positive effect of CO_2 concentration on the rice yield was highly overestimated and rice growth amount before heading such as biomass at heading and grain number were not reflected to rice yield even they are very closely related with yield in reality. Grain weight estimation module which was determined by grain number, biomass at heading, temperature and irradiation during grain-filling was developed to overcome these problems of ORYZA2000. Also using this sub-model, filled grain ratio was calculated. Finally, yield was calculated with yield components such as grain number and, filled grain ratio in contrast to original ORYZA2000, where yield is determined independently to yield components. Consequently, CO_2 after heading don't effect on the yield, and growth before heading can be reflected to the yield.

3.1. Simulation using modified ORYZA2000

In the simulation results using modified ORYZA2000, When cropping season was fixed, rice yield decreased by 4~35% as climate change. This yield decrease was caused by poor filled grain ratio, where filled grain ratio was decreased by high growing temperature and low irradiation after heading, however, grain number was increased by CO_2 fertilizer effect. When cropping season was changed, rice yield decreased by only 0~5% as climate change. This little yield decrease was caused by poor filled grain ratio, where filled grain ratio was decreased by only low irradiation after heading, however, grain number was maintained by CO_2 fertilizer effect even growing period before heading was shortened very much.

<<<Fig. 1>>

IV. DISCUSSION

According to the above results, when cropping season was fixed, major cause of rice yield decline by climate change was poor filled grain ratio by both of high temperature and low irradiation during grain-filling whereas fertility was decreased significantly in

only in 2071~2100. In addition, this high temperature and low irradiation can also lead to deterioration of grain quality such as chalky grain. When cropping season was changed, major cause of rice yield decline by climate change was also poor filled grain ratio by only irradiation decline during grain-filling as days go by in the latter of the year, especially at the high latitude. However, this irradiation decline was less than when cropping season was fixed. Resent, many researches have been focused on high temperature during grain-filling, but if cropping season is changed, high temperature during grain-filling will be not any more threats. Therefore, we need to develop rice cultivars resistant to low irradiation which can maintain high filled grain ratio under poor irradiation condition, and late maturity rice cultivars whose growing period is longer than the present medium-late maturity type.

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Table 1. Change of average temperature and rainfall compared with them of 1971~2000 in climate change scenario 'A1B' as global warming progresses.

Weather factor	2011~2040	2041~2070	2071~2100
Temperature increase	1.2℃	2.7℃	4.2℃
Rainfall increase	6.4%	18.0%	21.1%

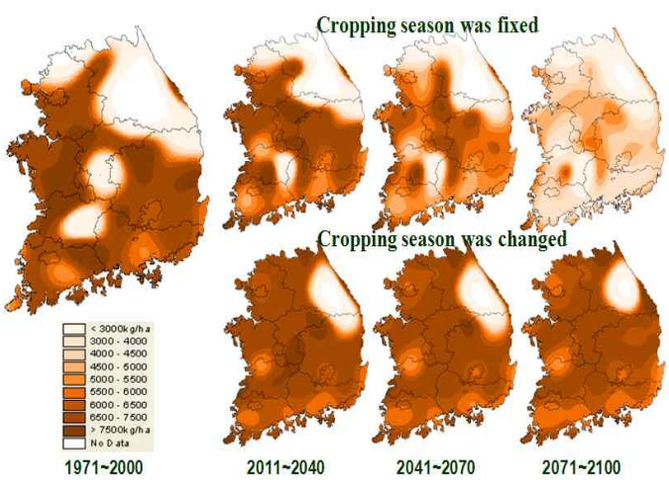

Fig. 1. Rice yield change as climate change when cropping season was fixed and changed, respectively