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FSM-Rice: a simulation study on rice morphology using functional–structural plant modeling

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Highlights: A functional-structural plant model for rice (FSM-Rice) was developed by linking an existing rice growth model (RiceGrow) with a detailed morphological model (RiceMoph) to realize dynamic visualization of 3D rice plant at organ, individual and population scales under different growth conditions and cultivars.

Keywords: Rice, OpenGL, visualization, morphological model, RiceGrow, functional–structural plant model (FSPM)

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important grain crops in China, its planting area accounting for 30% of all grain crops, and its yield for 40% of the grain yields. Rice plant architecture is one of the key factors related to its yield, which affects light distribution and photosynthesis in canopy. The modeling approach functional-structural plant model concerned with integration of architecture and resource allocation as aspects of plant function was developed in the mid-1990s. However, rice modeling using FSPM should be improved and developed in physiology and organ architecture descriptions. This study aimed at plant architecture modeling and visualization in rice, was to develop a functional-structural plant model in rice (FSM-Rice) by linking an existing physiological model in rice, RiceGrow (Tang et al. 2009), with a detailed morphological model (RiceMoph) which developed under different environmental conditions and cultivar types.

RESULTS

Based on time-course observations on morphological characteristics of organs (leaf, stem (tiller), panicle, and root) in rice under different environmental conditions and cultivar types, a morphological model (RiceMoph) was developed with growing degree days (GDD). The RiceMoph model allowed dynamic construction of geometric structure of rice plant, including morphological characteristics of leaf (length, width, angle and curvature), sheath and internode (width, length), panicle (length, width, curvature, branch, grain), root (length, number, diameter), and organ color sub-models. RiceGrow is a field scale, weather-driven, process-based dynamic simulation model, including 6 submodels for simulating phasic and phenological development, morphological and organ formation, photosynthesis and dry matter accumulation, yield and quality formation, soil water relations and dynamic nitrogen balance. FSM-Rice was developed by integration of RiceGrow model and RiceMoph model. The RiceGrow ran continuously and independently, was driven by data of weather, variety, soil and management, simulated the functional processes of rice growth and development and provided basic inputs for RiceMoph model, including development rate, population architecture, assimilate accumulation and partitioning, water and nitrogen factors. Visualization model was also developed to make the virtual rice more realistic by using OpenGL technology, including geometry, realistic rendering, organ deformation, texture, and illumination submodels. Dynamic visualization of 3D rice plant at organs, plant individuals and population scales under different cultivars and growth conditions were realized by using C# on the platform of .Net. Comparisons between virtual rice and real rice showed that visualization of 3D rice plant had a good prediction for dynamic changes of spatial morphology and color in rice plant. The results would support for rice production, breeding, research, and teaching.

LITERATURE CITED

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