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Preface

# Improving Agricultural Water Productivity to Ensure Food Security under Changing Environments

Changing environment poses serious threats to global food security due to changes in water supply and demand by altering the spatial and temporal distribution of rainfall, the availability of water, and other agricultural production factors (Alcamo et al., 2007; Hanjra et al., 2010). Food security is closely linked to water security, since food production heavily depends on freshwater availability around the world. Agriculture is the sector responsible for most water use, consuming 70% of total fresh water diversions in the world. Therefore, improving agricultural water productivity through integrated measures is an important measure for ensuring global water and food security.

Water shortage has seriously affected China's agricultural production (Brown et al., 1998; Oweis et al., 2003; Du et al., 2015). Over the last 50 years, China has achieved significant increases in grain production largely due to the expansion of irrigation. However, water resource distribution in China is highly uneven and limited water resources in the north China will significantly impact agricultural production. To make things worse, irrigation efficiency in China is only 52%. To mitigate the water shortage problem, there is a great need to reduce irrigation water use. However, simply reducing irrigation water without diligent planning will lead to reductions in local agricultural production, and thus pose a great risk to national food security. Consequently, how to improve agricultural water productivity becomes the key factor that strikes the balance between alleviating water shortage and maintaining high and stable agricultural production (Kang et al., 2016).

Therefore, it is critical to identify the key issues related to efficient water use in agriculture within the context of the present and future changing environment and to understand the mechanisms of water transformation and consumption in grain production at different scales. Improving agricultural water productivity through scientific and technological advancements and management reform will help us to achieve the balance of high-yield and saving-water, and to solve the current water crisis to ensure sustainable agricultural production and food security. This is a global priority.

To address those important issues, three workshops entitled "Water and Food Security under Changing Environments", "Irrigation in Action", "Agricultural Hydrology and Water Resources"were organized by the Center for Agricultural Water Research in China, China Agricultural University in 2015. The workshops were supported by the Innovation and Introduction of Oversea Talents Base (111 Plan) on Improving Water Use Efficiency in Agriculture (B14002), Innovative Research Group Program of NSFC "Coupling Multiple Processes of Hydrological Cycle and Improving Water Use Efficiency in Agriculture" (51321001), and the National Nature Science Foundation of China (91425302). The objective of the workshops was to bring together world experts in broad fields related to agriculture water productivity to promote international multi-disciplinary research and collaborations in order to improve water and food security within the context of water scarcity, land degradation and climate change. Over 200 scientists from the United States, Australia, Israel, New Zealand, Portugal, Denmark, Spain, Mainland China and Hong Kong participated in these workshops. Over 59 world-renowned experts in the field of environmental physiology and ecology, agricultural and eco-hydrology, agricultural water management, irrigation technology gave presentations on the topics related to water and food security. The topics included (1) crop water requirement measurement and estimation, (2) crop yield and quality responses to water stress: experiments and modeling, (3) fertigation with drip irrigation and sprinkler irrigation, (4) integrated measures for improving water productivity, (5) Multi-scale agro-hydrological modeling and (6) new technologies in agricultural water management.

The format of the workshops allowed participates to present their research regarding different aspects of agricultural water productivity. In each of the sessions, presentations were followed by active discussion leading to a summary of key points and focusing on the relevant research topics and research fronts on how to ensure water and food security under changing environment. All the participants agreed that a special issue on Improving Water Productivity for Food Security under Changing Environments should be planned in Agricultural Water Management. All the attendants considered improving agricultural water use efficiency through integrative measures to be an essential measure for ensuring food security. Improving agricultural water use productivity requires advancement of different fields from theories to applications and at multiple scales from molecular to regional scale.

This special issue of Agricultural Water Management brings together a selection of insightful papers that address some of the issues related to agricultural water use productivity and is mainly

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based on presentations from the three workshops. The aim of this special issue is to synthesize the symposium contributions in defining priorities, challenges and future directions for research in improving agricultural water productivity. This special issue covers broad topics and demonstrates concerted efforts to improve agricultural water productivity from different perspectives. This special issue begins with an overview of the motivation and most significant findings from the workshop presentations and discussions followed by papers covering the following areas:

(1) *National and regional scale agricultural water productivity*. The manuscripts related to this topic include: Improving agricultural water productivity to ensure food security in China under changing environment: from research to practice (Kang et al., 2016); Global synthesis of drought effects on cereal, legume, tuber and root crops production: a review (Daryanto et al., 2016); Agricultural production, water use and food availability in Pakistan: historical trends, and projections to 2050 (Kirby et al., 2016); Responses of yield and WUE of winter wheat to water stress during the past three decades—A case study in the North China Plain (Zhang et al., 2016b); Spatio-temporal distribution of irrigation water productivity and its driving factors of cereal crops in Hexi Corridor of Northwest China (Li et al., 2016d).

(2) *Measurement and estimation of crop water consumption*. The manuscripts related to this topic include: Evaluation of thermal remote sensing indices to estimate crop evapotranspiration coefficients (Kullberg et al., 2016); ASCE-EWRI standardized Penman-Monteith evapotranspiration (ET) equation performance in Southeastern Colorado (Subedi et al., 2016); Soil moisture sensor calibration, actual evapotranspiration, and crop coefficients for drip irrigated greenhouse chili peppers (Sharma et al., 2016); Assessing FAO-56 dual crop coefficients using Eddy Covariance flux partitioning (Anderson et al., 2016); Partitioning of evapotranspiration using a stable isotope technique in an arid and high temperature agricultural production system (Lu et al., 2016b); The energy balance and canopy conductance for a cotton field under film mulched drip irrigation in an arid region of northwestern China (Tian et al., 2016); Plastic mulch decreases available energy and evapotranspiration and improves yield and water use efficiency in an irrigated maize cropland (Fan et al., 2016).

(3) *Water productivity and optimal water and agronomic management practices*. The manuscripts related to this topic include: Assessing yield, water productivity and farm economic returns of malt barley as influenced by the sowing dates and supplemental irrigation (Paredes et al., 2016); Evaluation on the responses of maize (Zea mays L.) yield and water use efficiency to drip irrigation water under mulch condition in the Hetao Irrigation District of China (Liu et al., 2016); Spatial variability of grape yield and its association with soil water depletion within a vineyard of arid northwest China (Li et al., 2016b); Effect of soil moisture-based furrow irrigation scheduling on melon (Cucumis melo L.) yield and quality in an arid region of Northwest China (Wang et al., 2016b); Effects of different irrigation levels at different growth stages on yield and water use efficiency of Kenaf and crop water production function (Wang et al., 2016a); Water use efficiency is improved by alternate partial root-zone irrigation of apple in arid northwest China (Du et al., 2016); Improved water use efficiency and fruit quality of greenhouse crops under regulated deficit irrigation in northwest China (Yang et al., 2016b); Effects of water stress on processing tomato yield, quality and water use efficiency with plastic mulched drip irrigation in sandy soil of Hetao Irrigation District (Zhang et al., 2016a); Comparison of multi-levels water use efficiency between plastic film partially mulched and non-mulched croplands on eastern Loess Plateau of China (Gong et al., 2016); Efficacy of planting date adjustment as a cultivation strategy to cope with drought stress and increase rainfed maize yield and water-use efficiency (Lu et al., 2016a); Conserved water use improves the yield performance under drought in soybean (Glycine max L.) (He et al., 2016); Irrigation water salinity influences at various growth stages of capsicum annuum (Baath et al., 2016).

(4) *Effects of irrigation and fertilizer scheduling on yield and water use efficiency*. The manuscripts related to this topic include: Nutritional responses to soil drying and rewetting cycles under partial root-zone drying irrigation (Wang et al., 2016d); Potato performance as influenced by the proportion of wetted soil volume and nitrogen under drip irrigation with plastic mulch (Yang et al., 2016c); Effect of irrigation regimes and nitrogen rates on water use efficiency and nitrogen uptake in maize (Wang et al., 2016c); Moderate nitrogen fertigation reduces instantaneously photosynthesis rates but does not reduce grain yield and water use efficiency of field-grown winter wheat (Zhang et al., 2016c).

(5) *Improved irrigation technology and equipment*. The manuscripts related to this topic include: A sowing method for subsurface drip irrigation that increases the emergence rate, yield, and water use efficiency in spring corn (Mo et al., 2016); Development of a new underdrain for improving the efficiency of micro-irrigation sand media filters (Bové et al., 2016); Scheduling irrigation from wetting front depth (Stirzaker et al., 2016); Corn and sorghum ET and yield as affected by irrigation application method: SDI versus mid-elevation spray irrigation (Evett et al., 2016); Investigating irrigation scheduling for rice using variable rate irrigation (Vories et al., 2016).

(6) *Multiscale agro-hydrological modeling and decision support system in agricultural water management.* The manuscript related to this topic include: An improved analysis Hierarchy Process Method for the evaluation of agricultural water management in irrigation districts of north China (Sun et al., 2016); Modeling hydrological processes in oasis of Heihe River Basin by landscape unit-based conceptual models integrated with FEFLOW and GIS (Li et al., 2016a); Applying uncertain programming model to improve regional farming economic benefits and water productivity (Li et al., 2016c); Estimating the economic and environmental benefits of a traditional communal water irrigation system: the case of Muang Fai in Northern Thailand (Mungsunti et al., 2016); A flexible decision support system for irrigation scheduling in an irrigation district in China (Yang et al., 2016a); An irrigation schedule testing model for optimization of the Smartirrigation avocado app (Mbabazi et al., 2016); Water footprint assessment of main cereals in Iran (Ababaei et al., 2016).

These peer-reviewed papers reflect recent advances in improving agricultural water productivity for food security under changing environment in the world. We hope this special issue will encourage researchers worldwide to continue the efforts to develop novel ways to improve agricultural water productivity as we believe the research, development and innovation will help to maintain global food security.

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