Commentary

Where is the road to bio-water-saving for the globe?

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Abstract

The First International Conference on the Theory and Practices in Bio-water-saving (ICTPB) was held from May 21 to 25, 2006 in Beijing, China. This indicated that the work related to this hot topic on the globe has been paid more attention to. Most progress in this field has been presented from near 300 participating people worldwide, who were meeting together to discuss about the theory and practices of water-saving biology and how to serve global agricultural and ecological sustainable development. The work related to bio-water-saving has been involved in different scales and soil–plant root biointerfaces. On the basis of this background and in combination with the work from our laboratory and the center, we provided some ideas for global bio-water-saving in this paper, sharing the achievement in this field and advocating true bio-water-saving for the world and promoting the pace of global bio-water-saving.

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1. Introduction

Plants play the most role in nature, which is an obvious fact and has been strengthened by recent global climate change and food safety ([1]; Brian et al., 2005; Chaves et al., 2004; [2–12]). With progression of global urbanization and consumption of natural resources (especially, land and water), the issue of eco-environmental quality and its carrying capacity will meet serious challenge [13–16,3–9]. China is the biggest country of agriculture with the greatest population in the world, facing the more urgent water crisis [16–18,2,19,7–9,3–6]. For finding an efficient way to solving the above issue, The academic community and governmental organizations in China, University of

Lancaster in UK, and Journal of Experimental Botany held a related International Conference on “Water-saving agriculture and Sustainable Use of Water and Land Resources” on November 24–28, 2003 in Yangling (the National Agricultural Sci-Tech City), Shanxi, China. One month ago, the First International Conference on the Theory and Practices in Bio-water-saving was held for the same topic on May 21–25, 2006 in Beijing, China, which was organized by the Center for Agricultural Resources Research, Institute of Genetic & Developmental Biology, Chinese Academy of Sciences, and sponsored by Chinese Academy of Sciences and co-sponsored by People’s Government of Hebei Province of China, National Natural Science Foundation of China, Chinese Academy of Engineering, Shanghai Agrobiological Gene Center and Journal of Integrative Plant Biology. Under the above background and in combination with the work from our laboratory and the center, we provided a survey on the theory and practices in bio-water-saving in the world and some ideas for this hot topic in the present paper, aiming at promoting related academic exchange and the deep and systematical study

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of global bio-water-saving at different tempo-spatial scales and soil–plant root biointerfaces.

2. Plant biology is the solid foundation for global sustainable development (GSD)

Natural resources is the base for humankind's survival, in which water and soil are the most components with the reason that living organisms can depend upon the above to finish their life cycle and further contribute to natural cycle [20,21,14,16,22,7–9,23,24,3–6]. Because agricultural sustainable development (ASD) is the core for GSD, understanding of plant resources and reasonably utilizing them is a key issue, i.e. how to solve the problems related to ASD by the way of plant biology platform is the biggest challenge in the 21st century [1,25–28,15,10,23,24,3–6]. A 1970 Nobel Peace Prize winner, Norman E. Borlaug said in 2000 (see, the Preface of the First ICTPB and Ref. [12]) “How can we continue to expand food production for a growing world population within the parameters of likely water availability? The inevitable conclusion is that humankind in the 21st century will need to bring about a ‘Blue Revolution—more crop for every drop’ to complement the so ‘Green Revolution’ of the 20th century. Water use productivity must be wedded to land use productivity. Science and technology will be called upon to show the way”. It is a fact that plant biology will show the first way, which has been confirmed by the participants.

3. Plant physiology to plant functional genomics

Plant physiology is a powerful tool and the most important basis for water-saving biology. Modern molecular biology cannot substitute for it and the combination of both is the key for its wide application and perspectives [29,25,30,26,31,27,21,32,28,33,14,17,18,10,34,23,7–9,35–37]. At this ICTPB, Professor Sharp from USA reported the recent work of his laboratory, laying a stress on the importance of functional genomics in deep understanding for root growth maintenance during water deficits. Professor Bohnert from USA also reported his recent work on root transcriptomes: segment- and condition-specific complexity, emphasizing the importance of combining physiology with functional genomics in terms of exploring the adaptive mechanism of CAM plants. Australian scientist, Professor Turner made an excellent presentation on improving rainfall use efficiency in Australian agriculture, talking about the importance of plant physiology and soil science in bio-water-saving. Professor Davies (chief-in-editor for Journal of Experimental Botany) from UK brought his report on soil:plant signaling networks: manipulations to sustain plant productivity under deficit irrigation, discussing the mutual relationship between soil and plants in bio-water-saving. The famous plant molecular biologist, Professor Shinozaki Kazuo from Japan made his report on molecular responses and tolerance to drought stress in higher plants, emphasizing the importance of gene expression-regulation networks bio-water-saving by combining with the work of his laboratory for many years. Professor Zhang J.H. from Hong Kong made his report on physiology and agro-

nomic fundamental of water-saving agriculture, discussing the related issues of plant physiology as the base for water-saving agriculture. Professor Zhang J.S. from Beijing, China made his presentation on transcription factors, roles in plant stress tolerance. Academician of Chinese Academy of Sciences, Professor Liu C.M. from Beijing, China presented his report on water resource and development of water-saving agriculture and water-saving in China, stressing the importance of the combination of plant biology with other disciplines in water-saving agriculture. Academician of Chinese Academy of Engineering, Professor Shan L. from China made a presentation on water-saving agriculture and water use efficiency by plants, also emphasizing the importance of improving crop water use efficiency in the dryland farming of China. Many scholars from other parts of the world such as Italy, Iran, India, Germany, Mexico, France, Israel, Syria and Philippines also addressed their water-saving work.

4. The greatest role of plants in natural circle

Only plants provide human being with renewable materials, energy and food. Plants also improve the eco-environment on the globe in its special way [13,14,18,38,39,15,40,2,41,7–9]. Environmental stresses are mainly abiotic stresses, such as drought, salinity, extreme temperatures, chemical toxicity and oxidative stresses, which have been strengthened by increasing global climate change. These stresses have serious threats to world agriculture and the natural status of the environment. Increasing drought of arable land is expected to have devastating global effects, at least resulting in 65% land loss within the next 25–30 years, and up to 85–90% by the year 2050 [19,42,43,16,22,44,12,45,3–6]. Therefore, breeding for drought and salinity stress tolerance and other stresses in crop plants (for food supply) and in forest trees (a central component of the global ecosystem) should be given high research priority in plant biotechnology programs ([46–49]; Pastori et al., 2002; [50,37]). Molecular control mechanisms for abiotic stress tolerance are based on the activation and regulation of specific stress-related genes. These genes are involved in the whole sequence of stress responses, such as signaling, transcriptional control, protection of membranes and proteins, and free-radical and toxic-compound scavenging [51,7–9,24,52–54,32,55,56,34]. Currently, research into the molecular mechanisms of stress responses has started to bear fruit and, in parallel, genetic modification of stress tolerance has also shown promising results that have been applied to agriculturally and ecologically important plants [41,10,57,37,27,12]. All the above is related to plants. No doubt, plant measures are the most basic for GSD and plant biology is the most powerful tool for solving the urgent issues facing human being [68,69].

5. Engineering-water-saving measures must be combined with bio-water-saving measures

In practice, engineering-based water-saving is not the total meaning for bio-water-saving and is only the assistant method for bio-water-saving [27,12,19,2–6,22,40,23]. Some advances in engineering-water-saving have taken place, which was

described in this ICTPB, mainly covering natural rainwater utilization and optimum design of water sprinklers for irrigation. For instance, Director from Center of National Water-saving and Irrigation at Yangling, China, Professor Wu P.T. reported the recent work from his group. He and his group developed a high-efficiency water-saving irrigation system and established a better system for collecting and utilizing natural rainwater for water-saving agriculture in the Loess Plateau of West-China, obtaining a bigger effect in economics, eco-environment and society [58–66]. Other scholars from China reported their work related to bio-water-saving by using rice, spring wheat, maize, *Triticum aestivum* L., *Brassica juncea* L. and trees as experimental materials. Scholars from Iran exhibited their achievement in relation to bio-water-saving by applying tomato, chickpea, alfalfa, spring rapeseed, cotton cultivars and rice

as materials (see the abstract collection of ICTPB and net address). Participants generally shared the common idea that engineering-based water-saving must be combined with biology, in particular plant biology, which is the core of water-saving biology. Plant measures are the base for bio-water-saving on the globe [3–6,16–19,27,28,40,66–69].

6. Bio-water-saving is a great systematic engineering involved in many disciplines

With global climate change and eco-environmental worsening, issues resulting from water resources will be more urgent. GSD will encounter a dilemma. Bio-water-saving will face a more serious challenge. Bio-water-saving is a big systematic engineering, involving in biology, soil sciences, meteorology,

Fig. 1. Modern bio-water-saving technological system framework.

ecology, agricultural sciences, mathematics, engineering and others. Their coordinate efforts will confer global bio-water-saving a bright future. On the basis of current study from different disciplines, we chart a modern comprehensive agricultural bio-water-saving system, providing further reference for this hot topic in GSD (Fig. 1) and giving some suggestions.

- (1) Theory of water-saving biology should be richened and planned systemically, covering many disciplines (Fig. 1). Up to now, the plant physiology interface for water-saving is more matured, because many achievements and progress in this field have been obtained and applied in water-saving agriculture successfully on the globe. The core of water-saving biology is still how to explore and master the law that plants utilize water at physiological and molecular levels. This is why plant physiology (biology) plays the most important role in water-saving biology. Molecular biology will exhibit a new and wide perspective for water-saving biology.
- (2) An international water-saving biology association (IWSBA) should be established at once, which should include many experts from related disciplines and different parts of the world. This association should be responsible at least for planning the scope of water-saving biology and stimulating its development globally. In this association, at least three specialized committees should be established, including physiological water-saving, molecular biology water-saving and engineering-based water-saving.
- (3) The practical range of water-saving should be enlarged urgently. Currently, crop water-saving study has been paid to much attention, but trees and grass also need more attention.
- (4) Engineering-based water-saving research must be combined with biology, especially plant biology. In this aspect, development of harvesting natural rainwater technology is also an important job. From the angle of true meaning for bio-water-saving, plants should be the first vector for bio-water-saving. Efforts also should be made to establish bio-water-saving model parks in different parts of the world according to different rainfall of the region. Yangling Bio-water-saving Model Park on the Loess Plateau of West-China, which is affiliated to Center of National Water-saving and Irrigation at Yangling, Centre of Soil and Water Conservation and Eco-environmental Research, the Chinese Academy of Sciences and Northwest A&F University, is a good example.

In a word, terrestrial organisms have evolved from ocean, where water is rich. Water is the most important ecological factor impacting living. We must abide by the law that plants need water at their different growing-developmental stages of their life cycle to reach the aim of water-saving and better harvest, which is the pre-condition for any related water-saving measures and is the total for bio-water-saving (Fig. 1). We are sure that breaking-through in bio-water-saving will bring a revolution to current precise agriculture on the globe and provide a perspective platform for GSD.

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