Outlook and Application of Biological Water-Saving

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Abstract

Drought and water shortage have become a world-wide problem in recent years with the effect of global warming. Water-saving agriculture has become an inevitable direction of agronomy research, it has developed from practices through agronomic water saving to engineering water saving and to the approaches in biological water-saving. The essence of biological water-saving should be the high-efficient use of water through biological ways, namely the "utilization and exploitation of physiological and genetic potentials of organisms so as to acquire more agricultural output and better economic and ecological benefits by utilizing smaller or same amounts of water or poor quality water". As a systematic approach, biological water-saving should not only be applied with priority in crop production, but also in other aspects of agriculture and industries such as husbandry, aquaculture, landscaping, sewage water management, water and soil environmental conservations. Therefore, biological water-saving represents the human effort in the construction of a resource-saving and environmental friendly society.

Key words
Biological water-saving, water use efficiency, agriculture.

Media summary
Biology water-saving should be stressed for increasing water use efficiency in the areas face water shortage and pollution problems.

1. Development of the concept of water-saving agriculture in China

Water shortage is a severe problem in the 21st century all over the world. Agriculture consumes the largest part of water, about 60%-70% of the whole water consumption. How to use the limited water resource efficiently and keep a sustainable agriculture and economy has become a challenge issue.

China made many achievements in water-saving agriculture. In a history view, there are three stage of water saving agriculture in China as follows: agronomy water-saving→ engineering water-saving→ biology water-saving (Zhang et al.2007). Water-saving agriculture, suggested from the concept of water-saving in irrigated agriculture, by now, both water-saving agriculture and dryland farming can be called as high water use efficiency (WUE) agriculture. High WUE agriculture refers to a new farming system that integrates high-tech system with economy and market and strives for high WUE, high economic, ecological and social returns per unit water consumed. There are five targets of water-saving agriculture, the first is to raise

the efficiency of water resources, which is mainly realized by engineering water-saving; the second is to increase crop WUE and yields; the third is to improve its economic WUE; the fourth is to improve the WUE of animals and microbes through in-depth researches on biological water-saving; the fifth is to attract people's attention to ecological WUE of plants as the environment problems will become worsen in many regions in the future (Zhang 2003,2006).

In China, agriculture has been seen or will see three important stages, "comprehensive development with grain as the key link", "comprehensive development with money as the key link" and "harmonious development with water as the key link". Agriculture has been transforming and will transform from forestry and grassland agriculture through grain-production agriculture, grain-economy agriculture and then economic-grain agriculture to high WUE agriculture and forestry integrated agriculture (Zhang 2006).

2. New development of the concept of biological water-saving

The development of biological water-saving has experienced three stages, crop physiology water-saving（Shan et al.1991）, crop genetics water-saving (Shi 1999)，biological water saving that including water-saving by animals, plants and microbes (Zhang et al.2007). At present, biological water-saving has become a systematic engineering. The concept of biological water-saving is still expanding. It not only should be given the first priority position in crop production and be placed in an important position in vegetable, fruit and other economic plant productions; but also it has a great water-saving potential through animal breeding. Besides, it has very significance in landscape planting, sewage control, water and soil conservation and environment improving.

Therefore, we think that biological water-saving, or biological high efficiency water use, should be defined as "to produce more agricultural output and higher economic and ecological returns by utilizing and exploiting physiological and genetic potentials of living organisms (including animals, plants and microbes) with limited or same amounts of water or poor quality water resources".

3. Biological water resources

Biological water resources can be called as "green water" that refers to the total quantity of water resources contained within the bodies of organisms. As to the estimation of biological water resources, the global biological water resource reserve is 0.112（KM^3）, accounting for 0.0001 (%) of the total water reserve and 0.003 (%) of fresh water reserve (United Nations 1977). Compared with the above mentioned other water resources, biological water resources are especially precious, which are the only source of our food. And water is the blood of the biosphere and the decisive factor of the sustainable development of environment（Malin 2005）.Biological water is one of the central joints in the conversion of various water resources. Therefore, there are still large research space and development potentials for biological water saving.

4. The future of biological water-saving

The scarcity of freshwater is a difficult problem in the world. It is the common choice for the countries to develop water-saving society and improve the higher efficient use of water

resource. We consider that biological water-saving includes three levels of implication in agronomic term: one is to reduce water and soil loss by organism covering; the second is to reduce irrigation and soil water depletion by drought resistance and water-saving crop; the third is to improve WUE so as to produce more food and economic benefits by every drop.

4.1 Studies on the six kinds of water transformation systems with biological water–saving as its core.

Before 1980s, many studies focus on "transformation of three kinds of water" (rainwater→ ground surface water→ underground water), in 1990s, more researches focus on "transformation of four kinds of water " (rainwater→ ground surface water→ soil water → underground water) (Liu 1993); in 2000s, much studies focus on "transformation of five kinds of water " (rainwater→ ground surface water→ soil water→ plant water →underground water) (Kang et al. 1994; Wei et al.2000); Now, we think that the research should be carried out on the "transformation of six kinds of water" (the precipitation→ ground surface water→ sewage water→ biological water→ soil water→ underground water continuum). All kinds of human activities and industrial and agricultural productions change clean water into vast amounts of sewages in rural and urbane areas. As a result, Sewages have becoming a resource that must be recycled and then used. Therefore, sewage disposal has become a world-wide problem (Bao 2005). Living things can not only conserve water and soil, but also decontaminate sewage, for example, sewage water can by clear by many plants like as reed and other and animals and microorganisms et al. Therefore, biological water-saving can plays an important role in the transformation of six kinds of water.

4.2 To restructure cropping system aiming at biological water-saving

Although fallow can reduce nutrient and soil water consumption, but under certain circumstances, planting green manure plants in filed can increase soil fertility, or planting such short-growth crops as legume, buckwheat and oil sunflower can also use limited water efficiently and get much income. In humid regions and seasonally dry regions of South China such drought-tolerant crops as upland rice, maize, sorghum and wheat can be planted in the place of rice, potato can be planted on autumn- and winter-fallowed lands after rice harvesting (Lin 2005). In cold zone of north China, winter wheat expanding northward because of global warming in order to utilize soil water and other resources in autumn and winter, and to conserve water and soil, reduce sandstorm occurrence and improve ecological environment (Gao et al. 2005). Therefore, restructuring cropping systems and breeding and extending water-saving plant varieties will made biological water-saving and high-efficiency water use have a great potentials to be exploited.

4.3 Physiological regulation and genetic modification to improve crop water use efficiency

Now in-depth research on the physiological and genetic mechanisms of high WUE crops should be carried out on the levels of growth, development, morphology, structure, tissue, cell, molecule, gene metabolic regulation, genome, genetic engineering, breeding and improvement in the following aspects: (1) drought resistant mechanisms; (2) high WUE mechanisms, such as molecular biology mechanisms in WUE regulated by water channel

protein; (3) the mechanisms to increase the harvesting indexes (HI) of crops; (4) the coordination among drought resistance and high WUE and high yield; (5) the mechanisms to couple high use efficiencies of water and nutrients; (6) high efficient use and transport of water and light. The research about biological water-saving need to be reinforced and a project to study the mechanism and application of biological water-saving or the mechanism and application of the improvement in crop WUE should be organized, which will be of important significance to the developments of water-saving agriculture and sustainable agriculture.

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