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Studies on water-saving and high-yield cultivation techniques of super rice

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ABSTRACT

In recent years, the problems of food security and water shortages in the world have become more and more serious. The super hybrid rice has been applied on a large scale in China for its high yield,good quality and resisitance desease,which increases the market supply of rice in China. In this paper,some comprehensive technical measures with water-saving and high yield has been discussed,which include selecting fine combinations with strong drought resistance,nurturing vigorous seedling with water-saving technique, much early drying practice to control ineffective tillers, aerobic irrigation during the whole growth period and fully make use of natural precipitation in soil. Because of being more efficiently use of the resources of light, temperature, water, gas, fertilizer in paddyfield,the technolegy can markedly improved the yield and quality of super rice. The Methane emissions reduce 73.2%-85.0% by this technology during the whole growth period than that of submerged irrigation. According to our examination, this technology lead to rice sheath blight reduced by 25%, rice plant hoppers reduced by 46%,rice leaf folde reduced by 70% compared to conventional cultivation. So by this technology,the goal has been achieved with water-saving, low consumption, pollution reduction, high yield and efficiency in production of super rice.

KEYWORDS

Super rice;
Water-saving;
High-yield;
Cultivation techniques.

INTRODUCTION

Rice, consumed by two thirds of domestic in China,where is serious lack of water resources with only 2340m^3 freshwater per capita,which is only 1/4 on average amount in the world,furthermore, the distribution of water resources is extremely uneven and droughts frequently occurs in some region. And rice is also China's main food crops,sown 2.67×10^7ha in 2010[1]. According to the 2009 statistical bulletin of economic and social development released by China National Bureau of Statistics,at the end of 2009,the population in China is 1 334 740 000,therefore,there is a very large demand for rice. Cultivation of rice requires irrigation,which uses more than 60% of total agricultural water. For a long time,the traditional cultivation of rice continuously flood during the whole growth season,which seriously wastes water resource and can not reach the objective of high and stable yield[2]. In recent years, some super rice combinations have successfully been breeded and been released far and wide in China,with planting area accounted for about 30%

of rice total planting area in 2010 and averagely promoting about yield of 900 kg/ha[3]. Therefore,It has great significance to study and apply the water-saving technology with high-yield of super rice for the realization of China's food security and the efficient use of water resources. In this paper,the authors report the results of studing and practicing water-saving and high-yield cultivation of super rice for many years.

MAIN TECHNICAL MEASURES

Selecting the fine combination with strong drought resistance

Super rice has a fine plant type, vigorous growth, high seed-rate and yield potential,and its flourishing root system is benefit for its absorption on soil nutrients and increases resistance to water and nutrient stress,which is suitable for water-saving cultivation. Super rice belongs to a source-limited species with more grains per spikes,which can achieve high yield under condition of water-saving[4]. There are different drought resistance for different super rice combination. The high yield has also been come true on less soil moisture conditions in water-saving cultivation by appling Zhongzheyou 1, Yongyou 6, Yongyou 9, and other combinations with stronger drought resisitance in our practice.

Nurturing vigorous seedling with water-saving techniques

The nersery field is kept moist situation prior to the three leaf stage of seedling and is irrigated with shallow water level below 1-2cm or intermittently dehydrated after the three leaf stage of seedling. The field is almost kept moist situation during stage of nursery field,which can avoid to disturb the growth of seedling root system because of lack of oxygen and accumulation of harmful substances in soil. Techniques nurturing seedling with water-saving can also reduce the inhibition among the seedlings,avoid excessive growth of seedling and increase root development. Seedlings cultivated by water-saving have the subdued green and thick leaves, stronger and health plant, flat and width basal stem, more tillers and more developed root system,greater drought-tolerant ability, which is conducive to earlier tillering after transplanting, large panicles and high-yield.

Much early drying practice to control ineffective tillers

Much early drying practice can cultivate high-quality population with less peak of seedlings and less ineffective tillers. When seedlings in field arrive 65% to 75% of the plan panciles of high yield, drying practice is started;when water content in soil reduces to 70% field water capacity,the field is irrigated thin water layer,;And when field was naturally dried to 70% field water capacity,it is irrigated thin water layer once again; which is repeated several times and end by the actual effects of drying practice and growth of the seedlings in the field during (from the remainder of 2.9 to 1.9 leaf age). If the plots that are higher fertility,single cropping of rice, transplanting in little seedlings or varieties with higher tillering ability,the drying practice is implemented earlier. Lightly drying practice is carried out,which ends every time at not traping feet in the middle of the paddy field, not white in soil or in straight blades, slightly fading leaf. Drying practice can timely promote the development of rice roots, regulate growth between overground and underground part, form healthy stout stems and a reasonable plant type, increase spike rate,enhance the disease resistance and lodging resistance[5].

Aerobic irrigation during the whole growth period

(A) Promote tillering coming out earlier by shallow water after transplanting

After transplanting of the seedlings,it is irrigated 2 to 3 cm shallow water to promote coming out tiller as early as possible,but the field transplanting by throwing seedling should be kept moist and exposed overnigh to promote seedlings rooting,then it be irrigated shallow water next day after transplanting. The damp irrigation is adopted to heighten the temperature in paddyfield surface to promote onset of tiller and it should not submerged deep water for not inhibiting growth of tiller[6].

(B) Damp irrigation from booting to full heading

It is a critical period of requiring water, particularly sensitive to water, during meiosis of pollen mother cells, so the paddyfield should be kept 1-2cm shallow water layer. In other stage from booting to milky periods,the paddyfield should be maintained in the wet situation. Water-saving cultivation has change some bad condi-

tions in the traditional cultivation with submerged water for a long time which goes against high yield,such as inhibiting growth of root system by poor soil permeability,more reducing substances,which results in nutrient malabsorption in late period and premature senescence.

(C) Intermittent irrigation during filling period

Because of not using fertilizer and spraying pesticide,the field management focuses on water management during grain filling period. The intermittent irrigation with shallow water should be taken after heading in order to achieve coordination both water and air,to support the root growth by adequate air in soil, to increase grain weight by thriving leaf. During waxy maturity stage,it is irrigated with"running horse water"(irrigating thin water lever below 0.5 cm, the natural drying to 70% field water capacity again irrigated thin water layer below 0.5 cm,which is stop to irrigate until 5 to 7 days before harvest.

APPLING EFFECTS

Water-saving resource

In traditional rice cultivation,the field continuously maintains water layer during its whole growth stage with a lot of excess water hoarding in the field,which brings about water loss by underground seepage, evaporation and outflow[7]. In water-saving cultivation of super rice,aerobic irrigation is adopted during the whole growth period of rice,nurturing strong vigorous seedling by water-saving techniques in nursery stage,maintaining damp status with no water level in whole paddyfield period, bringing forward and prolonging drying practice period,so that the leakage and evaporation of paddyfield widely is declined. In addition,there is a very large space to accommodate the rain, so it makes full use of rainwater resources and effectively reduce losses of water. The dynamic water management technology which irrigates combined with the natural rainfall and just irrigates and not drain in principle,effectively improves the utilization of water resources. Production practice has proved that water-saving cultivation of super rice can save 30%-50% of irrigation water,which can effectively alleviate contradictions between the industrial and agricultural water supply,between urban and rural water supply and can also increases planting area of rice[8].

Reducing pollution

Methane is a greenhouse gas, which greenhouse effect is 30 times of CO_2. It was reported that methane accounted for 23% in greenhouse effect leading to climate warming[9]. Methane of emissions from paddy fields accounts for 20%-30% of its global emissions. Water-saving cultivation reduces methane emissions. According to measure, Methane emissions by water-saving irrigation during the whole growth period of super rice reduce 73.2%-85.0% than that of submerged irrigation[10]. So water-saving irrigation can effectively alleviate the greenhouse effect. The practice also show that using much early drying practice of super rice can avoid to increase emission of nitrous oxide (a greenhouse gas) because of increase of nitrate content in soil and denitrifying bacteria in soil caused by excessive roasted paddy fields in conventional cultivation[11]. At the same time, just irrigation and no drainage in principle not only saves water but also reduces the loss of NPK,other nutrients and environmental pollution.

Alleviating damage of pests and diseases

Based on using Yongyou 6, Zhongzheyou 1,etc which have a strong resistance to the main disease of rice both rice blast and bacterial blight and adopting water-saving irrigation technologies with much early drying practice, the damage of pests and diseases in field is alleviated. The main reason is that ineffective tillers are controlled, degree of closure in field and field humidity are reduced. In addition,air and light conditions in pdddyfield are improved by planting in wide and narrow row. According to our examination, water-saving irrigation technology lead to rice sheath blight reduced by 25%, rice plant hoppers reduced by 46%,rice leaf folde reduced by 70% compared to conventional cultivation. Water-saving cultivation combined to agricultural, biological and chemical control integrated measures to pests and diseases and applying pesticide of high efficiency,low toxicity and low residue can significantly reduces pesticide pollution in the production process.

Achieving high yield

Water-saving cultivation of super rice can still

FULL PAPER

achieve high yield under the conditions of saving amount of water[12]. This techniques can control ineffective tillers and form reasonable plant type, high quality population in mid and late period of super rice, which has good light distribution of population,high rate of net assimilation and robust individual. So the contradiction between source and sink is fundamentally eased. Water-saving cultivation increases soil aeration, develops well aerenchyma of plant sections,promotes exchange between air and soil gas,reduces toxic material in soil, which improves the root activity and the growth of seedlings[13,14]. In the water-saving cultivation,the temperature on surface of field during the day is higher,but it is significantly lower during the night than that in conventional cultivation,which is benefit for formation of yield. The water-saving cultivation can be more efficiently use of the resources of light, temperature, water, gas, fertilizer in paddyfield[15], so yield and quality of super rice can markedly improved.

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