

The Using Conditions and Developing Directions of Fertilizer-Zinc for Irrigated Rice in China

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ABSTRACT

Rice is the main food crop and is also sensitive to Zn deficiency. Zinc is a necessary nourishment element for the growth of irrigated rice. The usage of fertilizer-Zn was practiced as a valid and easy way to improve soil fertility, provide more Zn and to decrease Zn-deficiency in irrigated rice fields in China. In this paper, we summarize research progresses for the application method, fertilizer-Zn sources and the methodology of increasing fertilizer-Zn use efficiency. In addition to continuous increase in Zn-rates and the lack of adoption of new knowledge and technology in Zn management by farmers, we hypothesized that low indigenous soil-Zn supply, adoption of hybrid and super rice cultivars, improper timing of Zn application could be causes for the low fertilizer-Zn use efficiency in China. Future research work on improving fertilizer-Zn use efficiency of rice in China should focus more on improving the responsiveness of cultivars to Zn and on achieving optimal soil-Zn supply capacities.

INTRODUCTION

Since Somme (1926) confirmed that Zn was a nutritive element necessary for plants to grow and develop, the problems of Zn deficiency in soils have drawn more and more attention of many countries in the world (Hu et al. 1997). Zinc is one of the nutritive elements required for the growth and development of rice. Rice is very sensitive to Zn deficiency. Zinc deficiency usually reduces yield by 10 to 30%, seedlings can be destroyed or harvest rejected when rice suffers from severe Zn deficiency. The application of Zn fertilizer as a rapid and effective way to increase Zn content of soils can greatly reduce the adverse effects on rice. This paper reviews the application of fertilizer- Zn to irrigated rice in China.

1. Application of Fertilizer-Zinc to Crops in China

Rice is one of the staple crops in China. It is also very sensitive to Zn deficiency. Presently, there are 2 million hm² Zn-deficient irrigated rice fields in Asia, and about 40% of rice fields are not Zn-sufficient in China. To compound the problem, the heavy application of chemical N-P-K fertilizers has gradually decreased the amount of organic materials and trace elements such as Zn in soils. The Zn content of soil ranges from 3 to 790 mg/kg, and the average value is 100 mg/kg in China (Liu 1994). In addition, most of the Zn exists in an unabsorbed state in the soil. Zinc inefficiency has become one of the factors impacting rice productivity. Applying Zn fertilizer to the soil has been used widely as an effective and simple way to improve the fertilizer capability of soil and to correct Zn deficiencies in rice fields. The amount of Zn fertilizer applied has increased over the years. The Zn-fertilized area of various crops was over 0.67 million hm², and the amount of application reached 7,000 tons at the beginning of the 1980s. The Zn-fertilized area was over 1.3 million hm², and the

applied amount reached 17,000 tons in the mid 1980s. The area of Zn fertilization reached 10 million hm^2 and the amount of application 38,000 tons at the beginning of the 1990s, while 13.5 million hm^2 were supplied with trace fertilizers including Zn, and the amount of application reached 58,000 tons at the beginning of this century. The area of Zn-fertilizer application has still been gradually enlarging in recent years. Zinc applications to rice resulted in yield increase. The experiments conducted by the Soil Fertilizer Institute of China Agricultural Scientific Academy indicated that the rate of rice yield increased 10% after Zn fertilization application nationwide (Hu et al. 1997).

2. Application, Condition and Research Progress of Zinc Fertilization for Rice

Zinc fertilizer are mainly applied as $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ and $\text{ZnSO}_4 \cdot \text{H}_2\text{O}$ in China. These compounds are high in fertilizer-efficiency and can bring better result. Zinc fertilizer can be applied as ground fertilizer, root-dipping, seed socking, seed dressing and top dressing.

The critical index of effective Zn in the soil suitable for rice growth is 1.5 mg kg^{-1} (Xu 2003) (DTPA solution lixiviated). The rate of Zn-fertilizer utilization would not increase remarkably unless applied in paddy fields that are deficient in Zn (i.e., the Zn content is lower than this index). Presently, domestic research on improving the effect of Zn fertilization concentrates mainly on the blend application of Zn fertilizer with others. For example, if Zn fertilizer is applied after the application of composite fertilizers, such as N-P-K, it may significantly improve agronomic traits, including the effective panicle number, individual plant height and panicle length of rice, and qualitative characteristics, including the content of crude protein and starch in rice seeds. Combining Zn fertilizer with NO_3^- and SO_4^{2-} can improve the effect of Zn fertilization, reduce adverse impacts of a single-form Zn fertilizer on crude protein and starch accumulation in rice seeds, and strengthen rice against disease or adversity, thereby improve quality of irrigated rice and increase yield (Gong et al. 2004). However, Zn fertilizer should not be mixed with basic fertilizers, such as lime, plant ash, kiln ash and ammonia, or with pesticides including bordeaux liquid, Ca polysulfide and resin wash since these compounds would reduce the effect of Zn fertilizer.

Zinc fertilizer has a clear after-effect. The isotope-tracing method indicated that the rate of Zn-fertilizer utilization is 1.2 to 3.5% for early rice and 0.6 to 1.5% for the succeeding crop (late rice) based on applying $15 \text{ kg ZnSO}_4 \text{ hm}^{-2}$ (Deng and Xie 1999). This illustrated that large quantities of Zn fertilizer remained in the soil. Furthermore, the Agricultural Scientific Academy of Hubei Province reported that in the season of Zn fertilization, the yield of early rice increased 18.7%, up to 9.4% in the next year, and up to 5.5% in the third year. The after-effect of Zn fertilization one year later is similar to a successive Zn fertilization for three years, and the rate of yield increase is quite similar. It indicates that Zn has a longer residual effect in the soil, and it is unnecessary to apply Zn fertilizer every year.

3. Long Term Potential of Zinc Fertilizer in Chinese Rice Production

Most irrigated rice fields are on limy soils in China. The utilization-efficiency of Zn in these soils is very low, which impacts rice growth, development and productivity. Applications of Zn fertilizer to change soil-chemical properties and fertility is a typical, simple and effective way to increase Zn availability in the soil and to satisfy the Zn demand of rice. The application of Zn fertilizer became a necessary agricultural treatment to increase

rice yields in some area, and has gained economic benefits. However, the application of Zn fertilizer at the present is only equivalent to around 1/6 of the fields suffering from Zn deficiency. Therefore, a lot of work remains to be done for the extension of Zn-fertilizer applications in China. The applications of Zn fertilizer provide promise for achieving higher yields at lower costs. Multiple ways to apply and to use Zn fertilizers that are ready to be blended with several fertilizers and the ability to apply them in different rice growing stages make Zn fertilizers easier to extend and apply in China. Thus, Zn fertilizer should have an extensive prospect of application.

Very big genotype differences exist for the Zn nutrition of rice, which is another approach to resolve Zn insufficiencies in rice. Zinc-tolerant, high yield and high-effect rice genotypes which are suitable to specially appointed soils can boost the local agriculture. With the development of traditional breeding and modern molecular biology, the potential of sifting and cultivating genotypes with an efficient Zn nutrition is big. This aspect may solve the problem to some extent in the 21 century (Wang et al. 2003).

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