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Effects of Controlled Release Fertilizer on the Flag Leaves Senescence in Dry-land Wheat

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Abstract: In order to select a reasonable controlled release fertilizer application method to slow down the senescence of flag leaf in dry-land wheat. The effects of controlled release fertilizer on soluble protein content, MDA content, the Catalase (CAT) activity, the Superoxide Dismutase (SOD) activity on the flag leaves senescence in dry-land wheat had been studied in the open field with the variety wheat Jimai22. The results indicated that, the combination application of controlled release fertilizer with conventional complex fertilizer on wheat was more conducive to the promotion of the soluble protein synthesis and it controlled the increasing of MDA content in flag leaf more effectively than the application of conventional complex fertilizer or controlled-release fertilizer alone on wheat. And it was more conductive to control or delay the process of flag leaf senescence with better maintenance of the SOD activity. The treatments in application of controlled release fertilization alone were conducive to these treatments with conventional complex fertilizer alone. Among these treatments, T6 was the best fertilization method with the lowest flag leaf senescence speed.

Keywords: CAT activity, Dry-land wheat, MDA content, SOD activity, soluble protein content

INTRODUCTION

In recent years, China fertilization technological development has been in high speed with more and more types of fertilizer and the single fertilizer has been replaced by complex fertilizer. There is one new type of fertilizer called controlled release fertilizer and for the production of wheat; disposable fertilization can automatically provide a timely manner to the wheat nutrition to ensure normal growth and development of the wheat. Controlled release fertilizer has two-way adjustment for controlled release or sustained release, so that the supply of nutrient elements in the fertilizer can be synchronized to meet plant nutrient needs to achieve a dynamically balance, putting forward new ideas and ways to solve low utilization rate of fertilizer. Various countries are gradually recognizing the importance of improving fertilizer utilization and one of the most effective measures is to develop a new type of slow controlled release fertilizer by reduction and high efficiency (Junhai *et al*., 2002; Wang *et al*., 2007), from the point of view of changing fertilizer characteristics to achieve greatly improvement of fertilizer utilization. Research of a high concentration of controlled-release fertilizer, has gradually caught people's attention which has become one of the development directions of the fertilizer research. In addition, the application of slow-controlled release fertilizer on wheat not only has high efficiency production, energy saving and environmental protection significantly, but also saves time and efforts, which is popular with the farmers. Under the requirements of sustainable agricultural development, crop production on the promotion and application of controlled release fertilizer is imperative.

The grain filling process coincides with the aging process of the flag leaf and lots of previous findings have showed that wheat flag leaf senescence has a very large relationship to the damages of biofilm cells and structure and function of the other biological macromolecules by the increase in the number of leaves in reactive oxygen species as well as the reduction ability of active oxygen scavenging system (Fahong *et al*., 2001). Therefore, it is increasingly important to explore the effects of controlled-release fertilizer on wheat flag leaf senescence. There have been some researches on different fertilization mode like tillage to the growth and yield in wheat (Makino *et al*., 1984; Shi *et al*., 1999; Yan *et al*., 2001; Xiong *et al*., 2009; Guoqing and Yan, 2012a, b) as well as different blending fertilizer on senescence and yield in Winter Wheat (Jingtian and Yan, 2012; Liyuan and Yan, 2012). However, there is little research on the effects of controlled-release fertilizer on wheat flag

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Table 1: Design of treatments (g/pot)

	CK	T1	T2	T3	T4	T5	T6
CRF	0	18	15	12	9	7.5	6
CCF	15	0	0	0	9	7.5	6

*CRF = Controlled release fertilizer; CCF = Conventional complex fertilizer

leaf senescence. Thus, this experiment studied the controlled release fertilizer on wheat flag leaf soluble protein content, MDA content, Catalase Activity (CAT) and Superoxide Dismutase activity (SOD) in the open field with the variety wheat Jimai22. Select a reasonable fertilizer application method to lay a theoretical basis for lowest flag leaf senescence speed in dry-land wheat.

MATERIALS AND METHODS

Experimental design: This experiment was carried out in 2010-2011 in the open field of Qingdao Agricultural University (36.30°N, 120.36°E) with the variety wheat Jimai22 which was semi-winter wheat variety. The soil was sandy loam soil with soil organic matter content 11.09 g/kg, total N 1.01%, available nitrogen 84.12 mg/kg, available phosphorus 23.38 mg/kg and potassium 84.53 mg/kg and the pH 6.7. The brand of controlled release fertilizer was Aolindan produced by Kingenta's company; whereas the conventional complex fertilizer labeled YAN NONG complex fertilizer which was produced by YANNONG-Weifang Agricultural Chain Co., Ltd. The Formula of N-P_2O_5-K_2O of these both fertilizers was all 22-8-12.

This experiment designed 7 treatments which were detailed in Table 1. For each treatment there were 12 repeats, a total of 84 pots with each pot 3 seedlings. All fertilizers applied into the pot once with diameter of 30cm and a depth of 40 cm which was filled up with the air-dried soil transferred into it evenly in the upper layer 10-15 cm. They were planted on October, 15. All the pots were buried deeply in the field soil with 2 cm height above the ground. Pest control occurred during the wheat growth.

Items: In the grain filling period, the soluble protein content were measured on 7 days, 14 days, 21 days and 28 days after anthesis with Coomassie brilliant blue method (Lin *et al*., 1984), respectively. Determine Malondialdehyde (MDA) content, Catalase (CAT) activity and Superoxide Dismutase (SOD) activity in accordance with the methods of Bradford (1976), Giannopolitis and Ries (1977) and Wang *et al*. (1983).

RESULTS

Effects of controlled release fertilizer on the soluble protein content in wheat flag leaves: As was showed in Fig. 1, the soluble protein content in dry-land wheat flag leaves after anthesis turned out to be a first slow than fast declining trend and T6 was always at the lowest speed. Totally, the soluble protein content lowest for CK, of T4, T5, T6 higher than T1, T2, T3 and the higher soluble protein content of T2 could not catch up with T6. We can conclude that, the fertilization application of T6 was the most reasonable to maintain the soluble protein content.

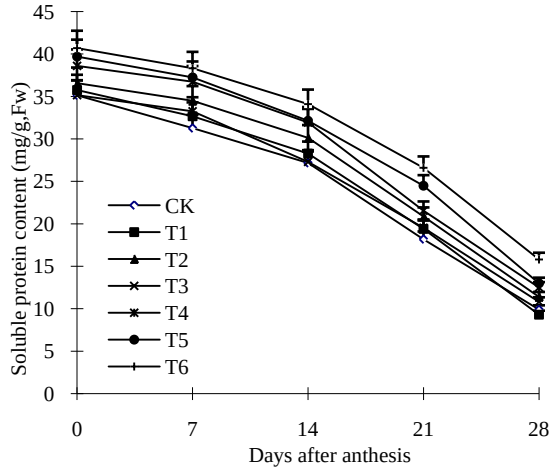

Fig. 1: Effects of controlled release fertilizer on the soluble protein content in wheat flag leaves

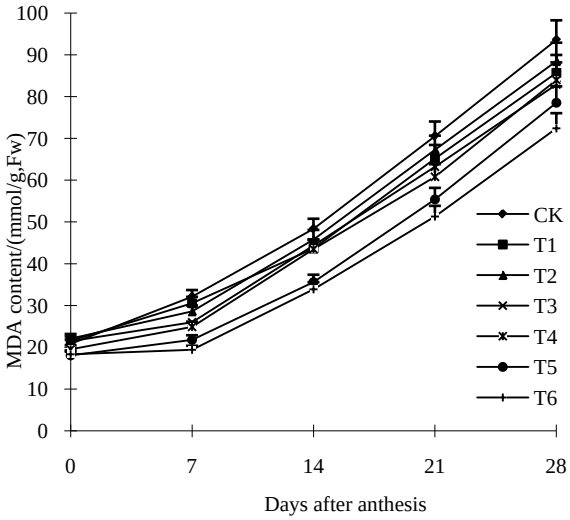

Fig. 2: Effects of controlled release fertilizer on MDA content in dryland wheat flag leaves

Effects of controlled release fertilizer on MDA content in dryland wheat flag leaves: We can find out from Fig. 2 that MDA content in dryland wheat flag leaves in all treatments were gradually increasing. MDA content of T4, T5, T6 was lower than T1, T2, T3 and CK the highest. At the same time, MDA content of the T2 was lower than T1, T3 and T6 lower than T4, T5. However, T2 was higher

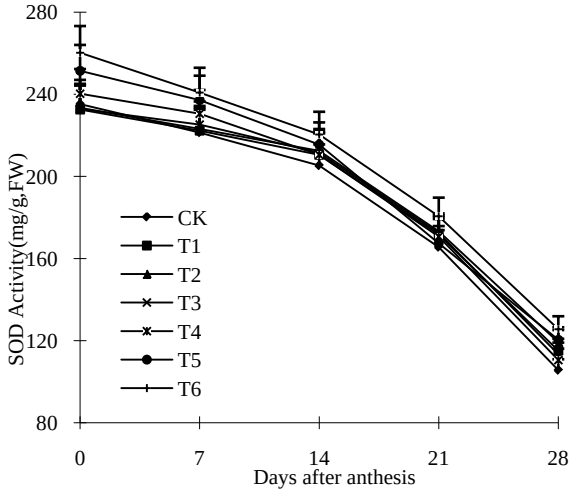

Fig. 3: Effects of controlled release fertilizer on SOD activity in dryland wheat flag leaves

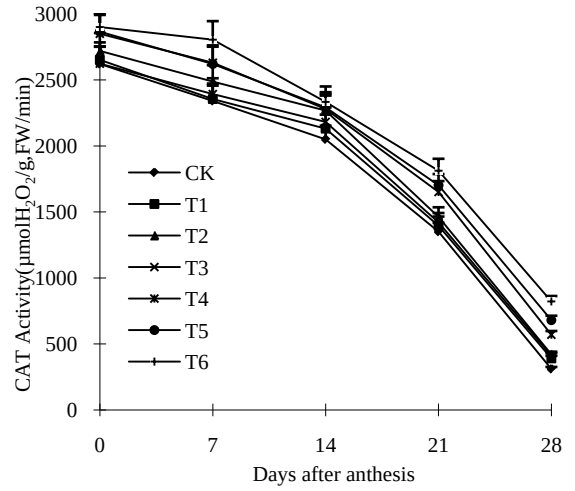

Fig. 4: Effects of controlled release fertilizer on CAT activity in dryland wheat flag leaves

than T6. There was no significant increasing trend over T5, T6. It revealed that, the combined application of controlled release fertilizer and conventional complex fertilizer reasonable was more conducive to delay the synthesis of MDA in wheat flag leaf through inhibition of membrane lipid peroxidation, thereby delaying the senescence of flag leaf.

Effects of controlled release fertilizer on SOD activity in dryland wheat flag leaves: SOD activity in dryland wheat flag leaves after anthesis of all treatments showed a first slower and then faster decline (Fig. 3). The SOD activity of T4, T5 and T6 was higher than other treatments followed by T1, T2, T3 and T6 the highest. It can be inferred that T6 was the most reasonable fertilization method to maintain the SOD activity. It showed that treatment T6 was more conducive to the maintenance of wheat flag leaf SOD activity, delaying the recession of leaf function, thus delaying the senescence of the flag leaf.

Effects of controlled release fertilizer on CAT activity in dry-land wheat flag leaves: We can make it out from Fig. 4 that the CAT activity in dry-land wheat flag leaves performed a first slower then faster decline trend. The decline magnitude of CAT activity in dry-land wheat flag leaves of T4,T5,T6 was less than other treatments with T6 significantly the least, CK the largest. The results indicated that, in the grain filling period after anthesis of wheat, T6 was more conducive to maintain the CAT activity.

DISCUSSION

Compared with complex fertilizer, controlled release fertilizer has the function of nutrient releasing and crop nutrient uptaking synchronously, overcoming the disadvantage of early oversupply and insufficient supply of late stage which sustained and highly efficient release nutrients gradually in accordance with crop nutrient demand throughout the crops growing season. Controlled release fertilizer could reduce the volatilization and leaching of fertilizer nutrients significantly and increase fertilizer use efficiency dramatically as well as reducing pollution of consumption of chemical fertilizers on the environment and groundwater (Wang *et al*., 2007). Different fertilization methods have different effects on dry-land wheat flag leaf senescence.

A lot of researches have shown that long-term evolution lead to the plant system protection mechanisms within the plant cells to defense against reactive oxygen radicals poisoned in which reactive oxygen scavenging enzyme system plays a very important role (Yi-zhi and Zhong-shu, 1983). The SOD is one of the protective enzyme active oxygen scavenging enzyme system (Daohong, 1983), while clear biological oxygen free radicals *in vivo* (Zhongping and Yuanlei, 1997). Within senescent leaves of plants, the soluble protein which is mainly RuBisCO play a role in plant metabolic activity, which serves as a key enzyme of the photosynthesis contributed to plant fixed CO_2 before leaf senescence (Makino *et al*., 1984). And the MDA is a major product of lipid peroxidation in the plant cell membrane system which also reflects the extent of lipid peroxidation (Fahong *et al*., 2001), thus the content of MDA can reflect the degree of senescence of the crop.

The results indicated that, in the same case of fertilization, the mixture of controlled-release fertilizer with conventional complex fertilizer on wheat was more conducive to the promotion of the soluble protein synthesis and it controlled the increasing of MDA content in flag leaf more

effectively than the single application of common complex or controlled-release fertilizer on wheat. And it was more conductive to control or delay the process of flag leaf senescence with better maintenance of the SOD activity. The treatments in application of controlled release fertilization alone were conducive to the treatments in conventional complex fertilizer alone. Among these treatments, T6 was the best fertilization method.

Only with the application of conventional complex fertilizer, the fastest senescence speed was due to the disadvantage of nutrient early oversupply and insufficient supply of late stage. However, with the combination of controlled release fertilizer and conventional complex fertilizer, it couldn't make sure the slowest senescence speed. Though the amount of fertilizer in T4 and T5 was more than T6, T6 got the slowest senescence speed. Comparing T4 and T6, the amount of fertilizer in T6 was about 30% less than T4 whereas the senescence speed of T6 was slower than T4. This may be because of the highest utilization of nitrogen of controlled release fertilizer which indicated that the fertilizer application of T6 could save the cost with highest efficiency.

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