

Research Article

The Effects of Controlled Release Fertilizer and Conventional Complex Fertilizer on the Photosynthetic Characteristics in Winter Wheat

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Abstract: The quantity and quality of the fertilizers affected the photosynthetic characteristic of the winter wheat. So, the rationality applied, reduced fertilizers not only can decline pollution for soil and ground water, but also save the cost. The quantity and quality of the fertilizers determine the relationship between the photosynthetic characteristics. Therefore, the different effects about the using of the Controlled Release Fertilizer (CRF) and the Conventional Complex Fertilizer (CCF) on photosynthetic characteristics in winter wheat were studied in the open field by pots experiment. The results showed that the SPAD value, photosynthetic rate and stomatal conductance of the treatments of the mixture of the CRF and equivalent CCF applied were higher than that of the treatments of CRF used alone and the control treatment, but the intercellular carbon dioxide concentration of both latter was higher than that of the former. So it can conclude that it was the best way to maintain higher photosynthetic rate in winter wheat by using the amount application and the way of application of fertilizer of T6.

Keywords: Controlled release fertilizer, photosynthetic characteristics, winter wheat

INTRODUCTION

The rational application of fertilizer in dry-land field has an important impact on the growth of winter wheat, the utilization ratio of fertilizer and quality of wheat (Yan *et al.*, 1999; Shi *et al.*, 2001; Fan *et al.*, 2005a, b; Jingdong *et al.*, 2013). In recent years, the studies confirmed that the increase application of nitrogen fertilizer could increase the rate of photosynthesis (Grassi *et al.*, 2002; Wu *et al.*, 2013) and there is a relationship between Nitrogen fertilizer and the rates of photosynthesis (Tian *et al.*, 2013). However, the fertilizers used excessively, especially such as the usage of the large number of nitrogen fertilizer, have caused adverse effects on the soil and environment (Magdalena *et al.*, 2003; Zhu, 2000). Presently, the amount of studies about the fertilizer on growth and development of wheat, dry matter accumulation, different tillages on dry-land wheat growth and Y (Guoqing and Yan, 2012a, b) were researched. And, the combined application of different fertilizers or that of mixed fertilizers also plays an important role on growth of winter wheat (Jingtian and Yan, 2012; Liyuan and Yan, 2012). The controlled release fertilizer is a high efficient utilization of fertilizer which the rule of nutrient release is accordance with the need of growth and development of winter wheat to the fertilizer. Therefore, the available

nutrient releasing rationally and timely of the controlled release fertilizer will have some impact on the growth and Y of winter wheat in the dry-land.

So, in this experiments, the effects of control slow-releasing fertilizer and conventional fertilizer on wheat photosynthetic characteristics was researched by applying controlled release fertilizer alone and the mixture of controlled release fertilizer and conventional fertilizer application in the winter wheat by pots in the open field in Qingdao. This would provide theoretical references for efficient use of the controlled release fertilizer on the winter wheat and was useful to gain the high-Y of wheat in the dry-land wheat growing areas.

MATERIALS AND METHODS

Experiment materials: The experiments were designed by potting with the wheat variety “Jimai 22” as the experiment material in the open field in the Qingdao Agricultural University (120.41°E, 36.10°N) in 2011-2012 years. The soil was sandy loam soil with soil organic matter content 11.09 g/kg, the total N 1.01%, available nitrogen 84.12 mg/kg, available phosphorus 23.38 mg/kg and potassium 84.53 mg/kg. The Controlled Release Fertilizer (CRF) of “Aolindan” label brand which was coated by sulfur and polymer was produced by Shandong Kingenta Company and the content of N-P₂O₅-K₂O of the CRF was 22-8-12. And

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Table 1: Quantity of fertilizer of different treatments (unit: g)

Treatments	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
SUM	15	18	15	12	18	15	12

the Conventional Complex Fertilizer (CCF) named label YAN NONG complex fertilizer which the nutrient content was 22-8-12 was produced by the YAN-NONG-Weifang Agricultural Chain Co., Ltd.

Experimental design: The experiments contained 7 treatments with 12 repeats in each treatment, a total of 84 pots with 3 seedlings per pot. And seeds were planted in the October 15th, 2011. The quantity of fertilizers applied was showed in Table 1. Each pot which the size was 30 cm in diameter, 40 cm in depth was filled with air-dried sandy loam soil. The fertilizers were applied on the 10-15 cm layer soil during the process of filling the pot with the soil dried in the air. All fertilizers for each pot were applied one-time. And water were supplied normally to make sure that the winter wheat grows naturally during the growing season and prevents the occurrence of the pests and diseases.

Experimental index: The photosynthetic parameters of winter wheat were measured by LI-6400 photosynthesis and chlorophyll value also was done by SPAD analyzer in May 10, 17 and 24, respectively.

RESULTS

The effects of different treatments on the SPAD value: In Fig. 1, the results indicated that the SPAD value of the treatments T4, T5, T6 with the mixture of the CRF and equivalent CCF applied was higher than that of the CRF used alone (T1, T2, T3) and the control treatment. Especially the T6 was the highest content, followed by T5 and T4 in the mixture of the CRF and equivalent CCF applied. In the group of the controlled release fertilizer applied alone group (T1, T2, T3), the T2 was highest. But the SPAD value of T6 was higher than that of T2. So, it showed that the controlled release fertilizer treatments can improve the level of SPAD in leaf of wheat and also showed that the SPAD value did not significantly increase with the increase of the amount of fertilizer.

The effects of different treatment on the photosynthetic rate in the winter wheat: It showed that the photosynthetic rate of the mixture of (T4, T5, T6) was higher than that of the treatments of the CRF used alone (T1, T2, T3). It was the same trend on the content of the chlorophyll (Fig. 2). The figure also showed the decrease of the photosynthetic rate of the treatment T6 was lighter than that of other treatments. So, the amount of treatment T6 of the CRF and equivalent CCF applied can make sure the need of photosynthesis of winter wheat.

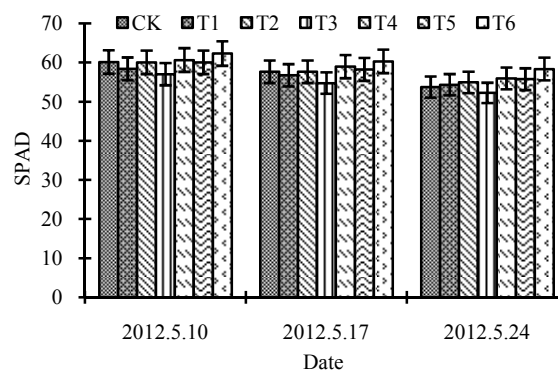


Fig. 1: The effects of different treatments on the SPAD value

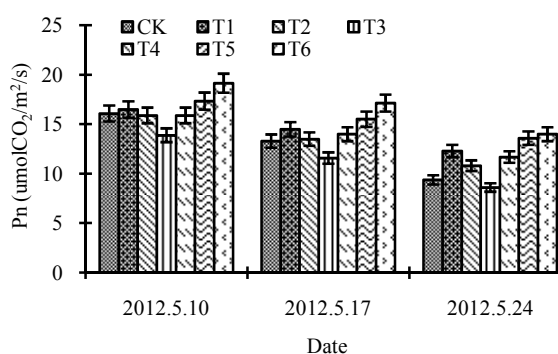


Fig. 2: The effects of different treatments on the photosynthetic rate in the winter wheat

The effects of different treatments on the stomatal conductance: The changes of the stomatal conductance directly affect the photosynthetic rate and gas exchange of the leaves winter wheat. The results showed that the trend of stomatal conductance of different treatments was decreased (Fig. 3). Among the different treatments, the stomatal conductance of the treatments with the mixture of the CRF and equivalent CCF applied (T4, T5, T6) was higher than that of the treatments of the CRF used alone (T1, T2, T3) and the control treatment. It is relative to the content of the chlorophyll and the photosynthetic rate. The results showed that the photosynthetic rate had a close relationship to the chlorophyll content and the stomatal conductance.

The effects of different treatments on the intercellular CO₂ concentration of winter wheat: From the Fig. 4 it indicated that intercellular CO₂ concentration gradually increased, the intercellular CO₂ concentration of the treatments with the mixture of the CRF and equivalent CCF applied (T4, T5, T6) was higher than that of the treatments of CRF used alone (T1, T2, T3) and the control treatment. It is opposite to the trend of the chlorophyll content and photosynthetic rate. The trend of intercellular CO₂ concentration was not positively correlated with stomatal conductance, so this showed that the change of intercellular CO₂ concentration not only was effected by stomatal factor, but also the non-stomatal factors.

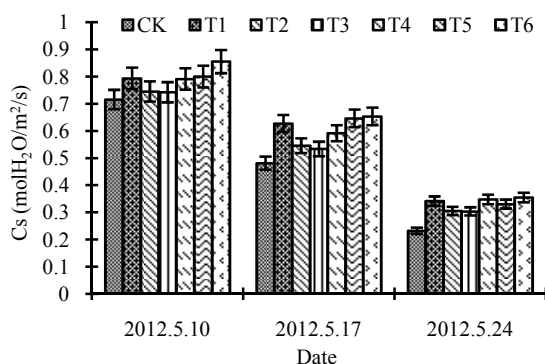


Fig. 3: The effects of different treatments on the stomatal conductance in the winter wheat

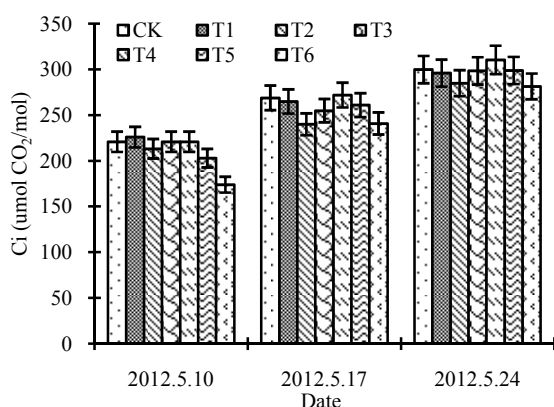


Fig. 4: The effects of different treatments on the intercellular CO₂ concentration of winter wheat

DISCUSSION AND CONCLUSION

The photosynthesis of crops has a close relationship with the quantity of fertilizer and the ways of application (Zhang *et al.*, 2007; Zhang *et al.*, 2011; Wu *et al.*, 2013). Different kinds of fertilizers can affect the chlorophyll content and therefore affect the photosynthesis and also can affect the dry matter accumulation of wheat and yield of wheat. The rational use of fertilizers (Guoqing and Yan, 2012a, b; Xiong *et al.*, 2009) has played a key role in the growth and Y of wheat. Most studies showed that the growth of wheat, the photosynthetic characteristics has a close relationship with the fertilizer application ways and fertilizers type. In this experiment, the chlorophyll content, photosynthetic rate and stomatal conductance of the treatments of the mixture of the CRF and equivalent CCF applied (T4, T5, T6) were higher than that of the treatments of the CRF used alone (T1, T2, T3), which is the opposite trend to the intercellular CO₂ concentration.

From Fig. 1 and 2, it showed that the photosynthetic rate had positively correlated with SPAD value. The content of chlorophyll affects immediately the photosynthetic rate. From the test data, the stomatal conductance had no positive relationship

with intercellular CO₂ concentration; the changes of intercellular CO₂ had positive relationship with non-stomatal factors, so it suggests that the improvement of photosynthetic rate can reduce intercellular CO₂ concentration. In this experiment, the treatments in the mixture of the CRF and equivalent CCF were higher than that of the treatments of the CRF used alone, in which the T6 was the highest. Therefore, the conclusion suggests that the amount application and the way of application of fertilizer of T6 was the useful to maintain higher photosynthetic rate in winter wheat.

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