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Research Article

Effects of Water-retention and Slow-release Fertilizers on Photosynthetic Rate of Summer Maize and Winter Wheat

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Abstract: To optimize cultivation and management of the biannual planting for winter wheat and summer maize in eastern Shandong, effects of different amount of water-retention and slow-release fertilizers on net photosynthetic rate and SPAD value of winter wheat and summer maize was studied in the field. The experimental materials were Jimai22 as winter wheat varieties and Heima 603 as maize varieties. The results showed that, in the case of same costs, considering the net photosynthetic rate and SPAD value of wheat and maize under different treatments, the treatment of single application of water-retention and slow-release fertilizers was superior than that of single application of compound fertilizer and the indicators of treatments applying both two fertilizers were higher than that of single application of either fertilizer and within a certain range, with the increasing ratio of the amount of the water-retention and slow-release fertilizers, the SPAD value maintained higher and the net photosynthetic rate was correspondingly faster.

Keywords: Net photosynthetic rate, SPAD value, water-retention and slow-release fertilizers

INTRODUCTION

Currently, due to the shortage of water resources in China in which agricultural water accounts for the most, how to maximize the use of natural precipitation to alleviate water deficit in dry-land agriculture becomes a major problem in the development of dry-land agriculture. Disposable fertilization of conventional fertilizer released nutrient soon which is not synchronized with the demand of crops for the nutrients. Thus it results in a waste of pre-nutrients and a lack of late nutrients in the crop growth, which makes fertilizer use efficiency low. And fertilization in many times is time-consuming and laborious which not only improves the production costs, but also creates more pollution. Shandong as one of the major grain producing areas in China is located in the north temperate monsoon climate zone. The province's annual average rainfall is of 676.5 mm and annual water surface evaporation of 1085 mm. It is a semi-arid and semi-humid area with inland arid extent gradually increasing from the southeastern Shandong to the northwest Shandong.

In recent years, with the emerging of controlled release fertilizer and water retention agent, related researches have gradually increased. Some researchers indicated that with the application of both controlled release fertilizer and compound fertilizer, it is conducive to the accumulation of dry matter in dry-land wheat after anthesis and helpful to increase the number of Grain number per spike and thousand kernel weight (Guoqing *et al*., 2013; Dandan and Shi, 2013a, 2013b), thereby increasing the yield of wheat to get the highest economic benefits.

Under the same amount of fertilizer, wheat in treatments with the combined application of half controlled-release fertilizer and half compound fertilizer was more conducive to promoting the synthesis of the flag leaf chlorophyll and soluble protein than single application of controlled release fertilizer. It could better control or delay the process of wheat flag leaf senescence so as to increase the accumulation of photosynthetic products (Dandan and Shi, 2013c; Jingtian and Yan, 2012; Liyuan and Yan, 2012) and achieve higher yield.

Some researchers have pointed out that the application of water retention agent would help alleviate drought stress of wheat (Yan and Shi, 2013a, b). Within a certain range, with applying water retaining agent, the relative water content of the soil in dry-land wheat and water use efficiency of leaf improved and it increased with the increasing amount of water retaining agent. Some studies (Zhanli *et al*., 2014; Meng *et al*., 2014) pointed out that water

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Table 1: Specific fertilizer of each treatment (kg/667 m^2)

	Winter wheat		Summer maize	
Treatment	Compound fertilizers	Water-retention and slow-release fertilizers	Compound fertilizers	Water-retention and slow-release fertilizers
CK	60	0	75	0
T1	45	5	60	5
T2	30	10	45	10
T3	15	15	30	15
T4	0	20	0	25

retaining agent could keep the water storage capacity of soil, reduce transpiration and water loss and adjust the pH of soil to make it more conducive to the growth of wheat.

Combining the capabilities of absorption and retention water of retaining agent with the controlled-release fertilizers to make the water-retention and slow-release fertilizers, which could realize the function of water absorption and retention and nutrients slowly released. It has great significance in agriculture in which dry-land accounts for 3/4 and it has become important areas of fertilizer innovation and researches (Wang and Wang, 2013). Water-retention and slow-release fertilizers have advantages of water conservation, drought resistance and high nutrient utilization, obviously higher yield, easy application, saving costs and high ratio of output to input.

There were some researches on preparation and materials screening of water-retention and slow-release fertilizers (Zhu *et al*., 2013; Wen *et al*., 2014; Zhao *et al*., 2014; Li *et al*., 2014), but few researches on photosynthetic rate of wheat and maize. This experiment studied the effect of water-retention and slow-release fertilizers on photosynthetic rate and SPAD value of winter wheat and summer maize. It would help to optimize cultivation management of wheat and maize, thereby to get higher yield and quality and reduce environmental pollution so as to provide a theoretical basis and technical support to water saving and high yield cultivation system of winter wheat and summer maize.

MATERIALS AND METHODS

Experimental design: The research group conducted field experiment from September, 2013 to October, 2014 in experiment base of Baoshan town Huangdao city (119.84° E, 36.03° N). Before the experiment, the organic matter content of soil was of 1.2%, total nitrogen of 1.3%, alkaline hydrolysis nitrogen of 90 mg/kg, available phosphorus of 35 mg/kg and available potassium of 79 mg/kg. Experimental materials were Jimai22 as wheat varieties and Heima 603 as maize varieties. The water-retention and slow-release fertilizers were made by research group in Qingdao Agricultural University. Kingenta bio-organic fertilizer and Kingenta compound fertilizer (N-P_2O_5-K_2O: 26-10-15) were made by Kingenta Ecological Engineering Group Co., Ltd. The costs of inputs among different treatments were the same, while the ratios of fertilizers were different. Wheat and maize relied on only natural precipitation during the whole growth period.

Wheat experimental design: This experiment was a randomized block design with 5 treatments and each treatment 4 replications. The residential area was of 20*20 m^2. Specific fertilizer was in Table 1. In addition, winter wheat applied 40 kg/667 m^2 of organic fertilizer and all fertilizers were disposable applied as basal fertilizers. Wheat was sowed on October 15, 2013 with sowing rate of 20 kg/667 m^2 and was harvested on June 16, 2014.

Maize experimental design: This experiment was a randomized block design with 5 treatments with 4 replications; and the residential area was of 20 * 20 m^2. Specific fertilizer was in Table 1 and all fertilizers were applied to the soil while sowing maize. Maize was sowed on June 17, 2014 with the remaining seedlings of 67500/hm^2 and was harvested on October 12, 2014.

Items and methods:

Photosynthetic parameters: After anthesis of winter wheat and maize silking stage, choose a sunny windless weather to measure net photosynthetic rate (Pn) at 9: 30-11: 00 with LI-6400 photosynthesis system produced by LI-COR of United States and to measure SPAD value with SPAD-502 chlorophyll meter.

RESULT ANALYSIS

Effect of water-retention and slow-release fertilizers on net photosynthetic rate in flag leaves of winter wheat after anthesis: From Fig. 1, the net photosynthetic rate of winter wheat flag leaves after anthesis showed an overall downward trend and the sequence was as following: T3>T2>T1>T4>CK. The net photosynthetic rate of treatment CK with application of only compound fertilizer in wheat flag leaf after anthesis was the lowest and lower than treatment T1 which was in single application of water-retention and slow-release fertilizers. And in the case of combining two fertilizers, with the increasing ratio of water-retention and slow-release fertilizers, the net photosynthetic rate increased.

Effect of water-retention and slow-release fertilizers on SPAD value in flag leaves of winter wheat after anthesis: From Fig. 2, since the beginning of flowering

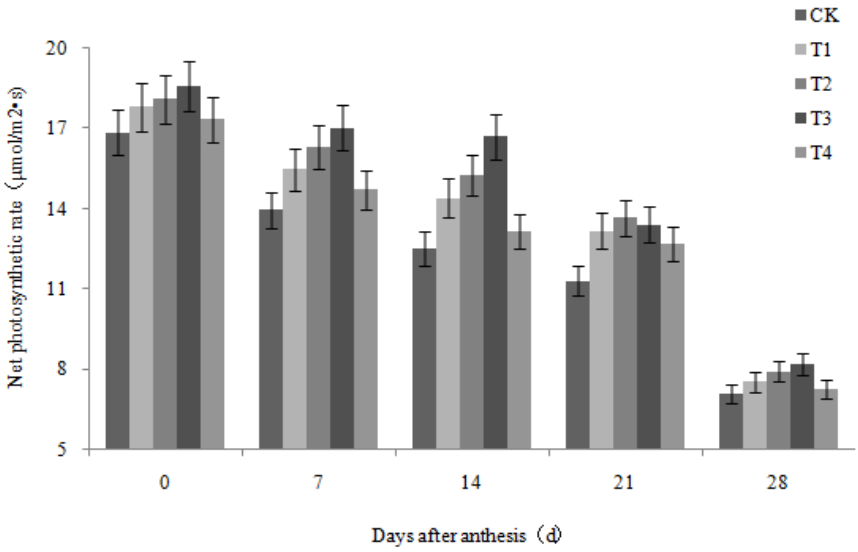

Fig. 1: Effect of water-retention and slow-release fertilizers on net photosynthetic rate in flag leaves of winter wheat after anthesis

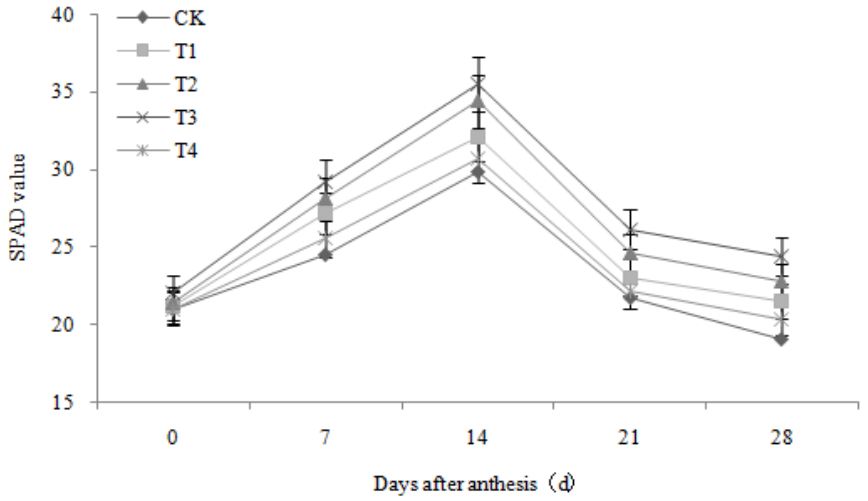

Fig. 2: Effect of water-retention and slow-release fertilizers on SPAD value in flag leaves of winter wheat after anthesis

stage, with the advance of the grain filling stage, SPAD value of flag leaf showed a first increasing and then decreasing trend and reached the maximum at 7 days after anthesis. During each sampling period, treatment T3 always had the highest SPAD value and CK the lowest. At 14 day after anthesis, T3 had the slowest rate of decline with the smallest decline extent. Twenty one days after anthesis, SPAD value of each treatment was in the trend as following: T3>T2>T1>T4>CK.

Effect of water-retention and slow-release fertilizers on net photosynthetic rate of summer maize in ear leaves: From Fig. 3, the net photosynthetic rate of summer maize ear leaves from earlier silking to 45 days after silking, showed a first increasing and then declining trend and it reached the maximum at 15 day after silking. In different stages for net photosynthetic rate of ear leaf showed the sequence: T3>T2>T1>T4> CK. The net photosynthetic rate of treatment CK that only applied compound fertilizer was the lowest, lower than treatments that applied water-retention and slow-release fertilizers. In the case of combining these two kinds of fertilizers, within a certain range, with the increasing proportion of the amount of water-retention and slow-release fertilizers, the net photosynthetic rate increased.

Effect of water-retention and slow-release fertilizers on SPAD value in ear leaves of summer maize: From Fig. 4, from the earlier days of silking to 45 days after silking of maize, the SPAD value of ear leaves in summer maize showed first increasing and then

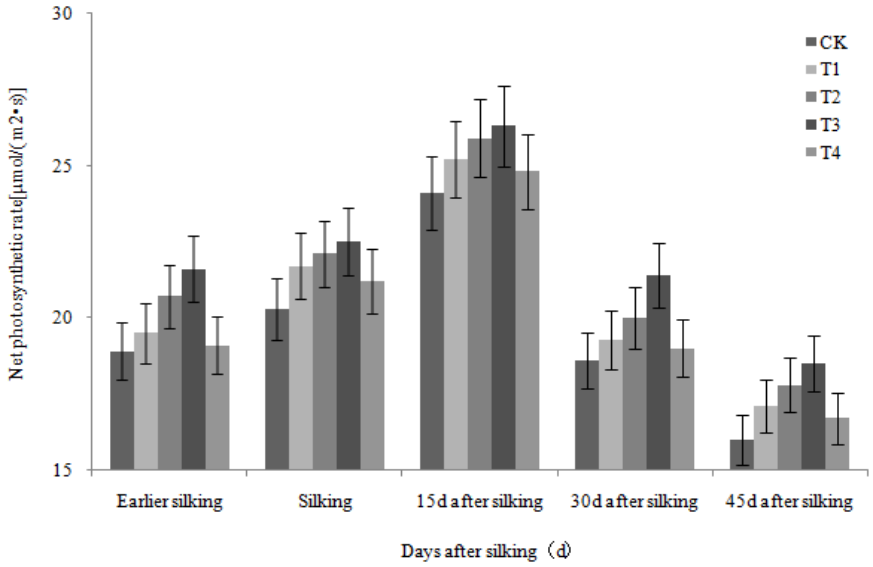

Fig. 3: Effect of water-retention and slow-release fertilizers on net photosynthetic rate of summer maize in ear leaves

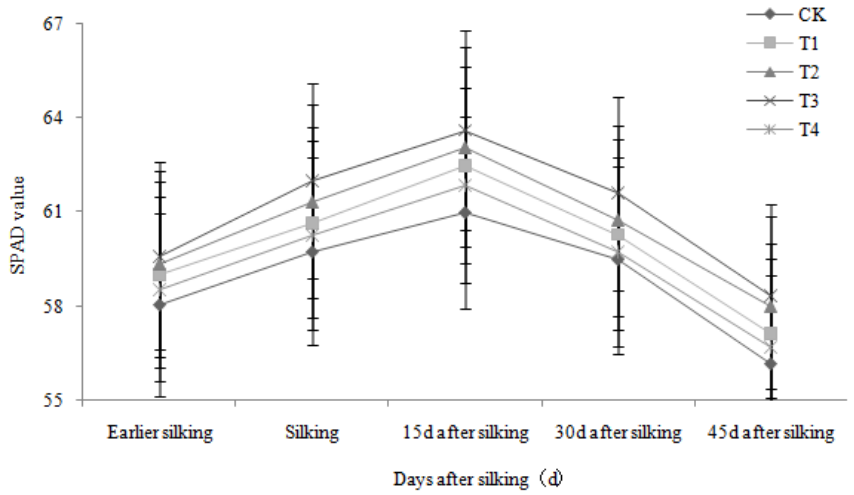

Fig. 4: Effect of water-retention and slow-release fertilizers on SPAD value in ear leaves of summer maize

decreased trend. And it reached maximum at 15 days after silking. In earlier silking, there was no significant difference in SPAD value of treatments. And the difference of silking stage was significant. There was no significant difference from 15 to 45 day after silking. The overall performance of treatment was in the sequence: T3>T2>T1>T4>CK.

DISCUSSION AND CONCLUSION

Photosynthesis of crops relies on absorption and utilization of light energy by the chlorophyll. It is the reaction of crop grown conditions which is related to the level of yield. Only by grasping the photosynthetic variation of the wheat flag leaf and corn ear leaf whose leaves are of the representatives, can we understand their growth and development.

With the promoting of the growing process, the chlorophyll content of wheat and maize in water-retention and slow-release fertilizers treatment still maintained a high level. It may be due to the function of absorbing water and retention water of water-retention and slow-release fertilizers, which increased water use efficiency on soil of wheat and maize. At the same time it achieved the purpose of slow release fertilizer to meet the needs of late growth of wheat and maize which was helpful to improve the photosynthetic rate, so as to achieve the purpose of improving yield.

This study showed that the net photosynthetic rate was in the same trend with chlorophyll content of maize ear leaf. And in the case of same costs, considering the net photosynthetic rate and chlorophyll content of wheat and maize under different treatments, the treatment of single application of water-retention and

slow-release fertilizers was superior than that of application of compound fertilizer only; and the indicators of treatments applying both two fertilizers were higher than that of single application of either fertilizer and with the increasing amount of water-retention and slow-release fertilizers, the SPAD value maintained higher and the net photosynthetic rate was correspondingly faster.

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