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**Research Article**

# Effects of Water Retaining Agent on Photosynthetic Characteristics of Dryland Wheat

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**Abstract:** To improve the drought resistance of dryland wheat, the effects of different amount of water retaining agent on chlorophyll content (SPAD), net Photosynthetic rate (Pn), stomatal conductance (Gs), intercellular $CO_2$ Concentration (Ci) and Transpiration rate (Tr) of dryland wheat were studied with Jimai 22 as experimental material. The results showed that, under conditions of this experiment, when the amount of water retaining agent was in range of 0-1 kg·667 $m^{-2}$, with the increase in the amount of water retaining agent, the chlorophyll content (SPAD), net Photosynthetic rate (Pn), stomatal conductance (Gs) and Transpiration rate (Tr) in dryland wheat increased and the intercellular $CO_2$ Concentration (Ci) decreased; while the amount of retaining agent was in range of 1-2 kg·667 $m^{-2}$, with the increase in the amount of retaining agent, chlorophyll content (SPAD), net Photosynthetic rate (Pn), stomatal conductance (Gs) and Transpiration rate (Tr) of dryland wheat decreased and intercellular $CO_2$ Concentration (Ci) increased. The best application amount of water retaining agent was 1 kg·667 $m^{-2}$.

**Keywords:** Chlorophyll content (SPAD), dryland wheat, intercellular $CO_2$ Concentration (Ci), net Photosynthetic rate (Pn), stomatal conductance (Gs), Transpiration rate (Tr)

## INTRODUCTION

Water has become critical resources constraint to China's agricultural safety in production due to the shortage of water resources of China and the unevenness distribution of spatial and temporal of geographically, so that to develop the efficient water-saving agriculture is the only way for Chinese agricultural sustainable development. To use the water retaining agent in wheat production is a new approach for drought-resistant research in wheat. Water retaining agent is the polymer compound granules, also known as the soil water, high water-absorbing agent, moisturizing agent, polymer water-absorbing agent, which is in use of strongly water-absorbent resin with high water absorption water retention capacity (Zhang and Bai, 2012). It can absorb the water into the hundreds even thousands of times the equivalent of its own weight. Water retaining agent has the capacity of repeatedly absorbent and releasing water. It swelling to gel after absorbing, with slow release of water which is absorbed by crops, will enhance soil water retention and reduce water deep leakage and loss of soil nutrients and improve water use efficiency. It is increasingly favored by people as the soil of the "mini-reservoir" (Yang *et al*., 2010a). In addition, water retaining agent has a good fertilizer capacity and it has good adsorption capacity for a variety of mineral ions in the soil as a polymer electrolyte. When the nutrients in the soil are sufficient, the water-retaining agent adsorbs nutrients and can release them to meet crops normal physiological and biochemical needs in growth and development. Moreover, due to large heat capacity of water, the water-retaining agent can regulate soil temperature by absorbing large amount of water, so that the soil temperature won't cause the occurrence of sudden changes with ambient conditions changes and reducing the temperature difference between day and night effectively which is conducive to crop growth. When the water retaining agent is applied into the soil, with swelling and dehydration contraction, the surrounding soil becomes loose by the compaction which will increase soil porosity and improve soil permeability conditions. With the decrease of root growth resistance, the soil microbial environment is improved which will be conducive to microbial growth so as to improve the utilization efficiency of soil organic matter (Li and Bai, 2012). Water retaining agent's ability to retain water, nutrients and characteristics to improve physical structure of the soil will provide good conditions for the crop growth and nutrient absorption of underground portion and lay a solid foundation for the normal growth of crops aboveground.

Currently there has been a considerable amount of researches about retaining agent on growth and the

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effect of soil moisture in wheat (Sui *et al*., 2008; Guan and Wu, 2010; Yang *et al*., 2010b, 2011b; Bai *et al*., 2012; Zhang *et al*., 2012). Some did researches on response of water use of winter wheat at different growth stages to nitrogen fertilizer and water-retaining agent (Yang *et al*., 2012) and proved the response of photosynthetic parameters of winter wheat before and after re-watering to different rates of water-retaining agent (Yang *et al*., 2011a). Some researchers proved the effects of retaining agent on leaf water use efficiency and yield in dry-land wheat (Yan and Shi, 2013). While there is little research of effect of retaining agent on photosynthetic characteristics of wheat (Zhang and Ma, 2008; Yang *et al*., 2011c), this paper studied the effect of water-retaining agent on photosynthetic parameters and chlorophyll content in dryland wheat so as to provide a theoretical basis to improve the drought resistance of dryland wheat.

## MATERIALS AND METHODS

**Experimental design:** The experiment was carried out in experimental base of Qingdao Agricultural University (35°46'N, 119°56' E) from October, 2012 to June, 2013. Before the experiment, the soil organic matter content was of 1.2%, total nitrogen of 1.8%, available nitrogen of 201 mg/kg, available phosphorus of 56 mg/kg and available potassium of 180 mg/kg. This experiment used water retaining agent provided by Dongguan AnXin water retaining Co., Ltd. The conventional complex fertilizer labeled YAN NONG complex fertilizer was produced by YANNONG-Weifang Agricultural Chain Co. Ltd. N-P2O5-K2O of the complex fertilizer was 22-8-12.

In this experiment there was a randomized block design with 5 treatments which were 0 kg•667 $m^{-2}$ (control, CK), 0.5 kg•667 $m^{-2}$ (T1), 1 kg•667 $m^{-2}$ (T2), 1.5 kg•667 $m^{-2}$ (T3) and 2 kg•667 $m^{-2}$ (T4). Each treatment repeated 3 times, leaving observations road of 0.50 m wide between repeated treatment, leaving inter-cell isolation region of 0.3 m wide, located protected area around the experimental plots and the residential area of 12*15 m. There was no irrigation among the wheat growth period. Complex fertilizer was applied once as base fertilizer before sowing and the dosage was 50 kg•667 $m^{-2}$. The sowing date was October, 2012. Wheat sowing rate was 12 kg•667 $m^{-2}$. The specific amount of water retaining agent and complex fertilizer was shown in Table 1.

Table 1: Corresponding to the different treatments retaining agent

| Treatment | CK | T1 | T2 | T3 | T4 |
|---|---|---|---|---|---|
| Water retaining agent (kg·667 $m^{-2}$) | 0 | 0.5 | 1 | 1.5 | 2.0 |
| Complex fertilizer (kg·667 $m^{-2}$) | 50 | 50 | 50 | 50 | 50 |

**Items and methods:**

**Chlorophyll content:** To measure the chlorophyll content with SPAD-502 chlorophyll meter measurement on April 27, May 14, May 21, May 28 and June 4, respectively.

**Photosynthetic parameters:** To measure the net Photosynthetic rate (Pn), stomatal conductance degree (Gs), Transpiration rate (Tr) and intercellular $CO_2$ Concentration (Ci) with LI-6400 photosynthesis measurement in sunny windless weather at 9: 30-11: 00 in the morning in the heading, flowering and grain filling stage of dryland wheat, respectively.

## RESULTS AND ANALYSIS

**Effects of different amount of water retaining agent on SPAD value of dryland wheat:** From Fig. 1, the overall chlorophyll content of dryland wheat under different treatment showed a first increase and then declining trend and the chlorophyll content of T2 in each period always be the highest, CK the lowest. The results showed that: water retaining agent better maintained the chlorophyll content of dryland wheat and in a certain range, with the increase in the amount of water retaining agent, the chlorophyll content of dryland wheat increased and then decreased gradually. In heading, flowering and grain filling stage of wheat, treatment T2 increased the chlorophyll content of dryland wheat significantly which was conducive to the absorption of light energy and the accumulation of photosynthetic products.

**Effects of different amount of water retaining agent on Pn of dryland wheat:** From Fig. 2, with the increase in the amount of water retaining agent, the Pn of dryland wheat increased gradually from heading to flowering stage and showed a downward trend after the

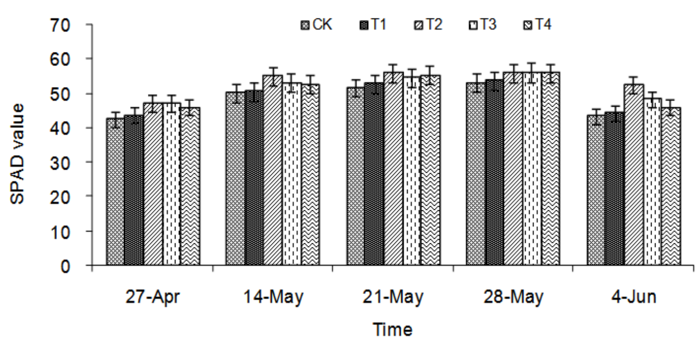


Fig. 1: Effects of different amount of water retaining agent on SPAD value of dryland wheat

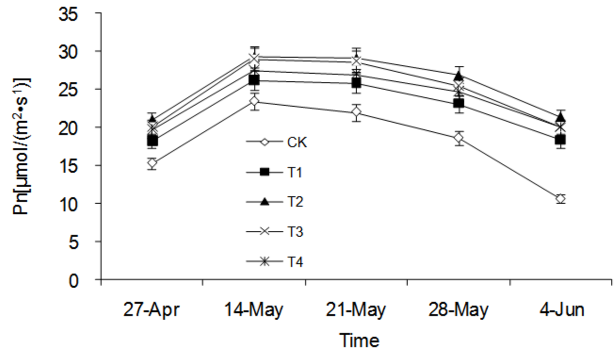


Fig. 2: Effects of different amount of water retaining agent on Pn of dryland wheat

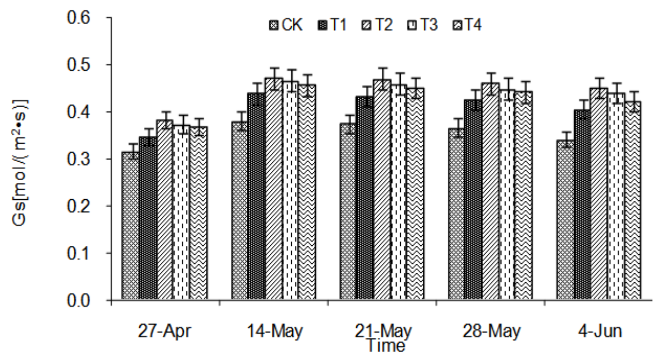


Fig. 3: Effects of different amount of water retaining agent on Gs of dryland wheat

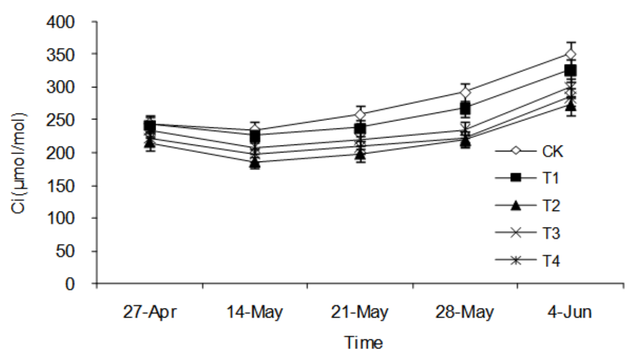


Fig. 4: Effects of different amount of water retaining agent on Ci of dryland wheat

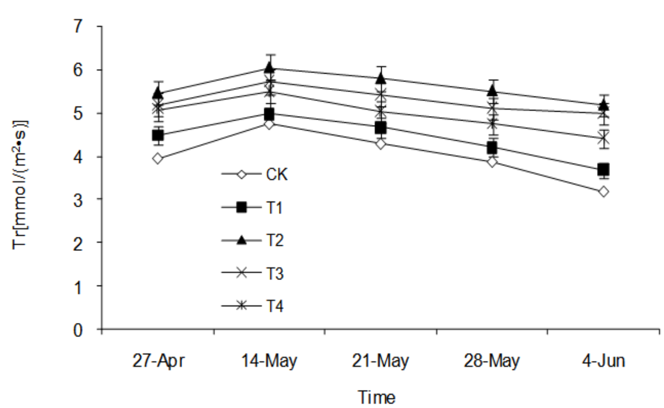


Fig. 5: Effects of different amount of water retaining agent on Tr of dryland wheat

flowering stage. The Pn of dryland wheat under different treatment was in the following sequence: T2>T3>T4>T1>CK. The results showed that: water retaining agent increased Pn of wheat and in a certain range, the Pn increased with the increasing amount of retaining agent and began to decline over a certain amount. Only applied water-retaining agent rationally such as T2, can the wheat obtain more accumulation of photosynthetic substances.

**Effects of different amount of water retaining agent on Gs of dryland wheat:** From Fig. 3, the Gs of wheat showed a first increase and then decrease trend and the overall in different growth period was in the following sequence: T2>T3>T4>T1>CK. The results showed that: water retaining agent improved Gs of dryland wheat and in a certain range, the Gs increased with the increase amount of water retaining agent. Treatment T2 would improve Gs of dryland wheat.

**Effects of different amount of water retaining agent on Ci of dryland wheat:** From Fig. 4, the overall Ci of dryland wheat showed a downward trend from the heading stage to flowering stage and an upward trend after that. But the specific performance of each period was: T2<T3<T4<T1<CK. The results showed that: water retaining agent reduced the Ci significantly and in a certain range, with the increase in the amount of water retaining agent, the Ci of dryland wheat firstly decreased and then increased.

**Effects of different amount of water retaining agent on Tr of dryland wheat:** From Fig. 5, from the heading to flowering stage, Tr of dryland wheat gradually increased and it gradually decreased from flowering to grain filling stage, but each period showed the following sequence: T2>T3>T4>T1, CK the lowest. The results showed that: water retaining agent help improve Tr of dryland wheat and in a certain range, with the increase in the amount of water retaining agent, Tr gradually increased. Tr of wheat under treatment T2 always was the highest.

## DISCUSSION AND CONCLUSION

The photosynthetic characteristics and chlorophyll content of different growth stages of wheat were different which were determined by the physiological characteristics of growth stages. The photosynthetic rate, stomatal conductance, intercellular $CO_2$ concentration and chlorophyll content of each treatment in this experiment of grain filling stage were higher than heading stage. Because moderate drought may help maintain higher chlorophyll content in grain filling stage to more efficient use of energy which will help increase wheat photosynthetic rate.

Deficit of soil water lead to crop reduction easily and the properties of retaining water and releasing water of water retaining agent can effectively alleviate the drought and reduce crop water stress so as to meet the needs of normal crop growth and development. Currently there are some differences about appropriate amount of water retaining agent among the researches. Some researchers (Yang *et al*., 2010a) suggested that photosynthetic rate, transpiration rate were the highest with 60 kg/hm$^2$ retaining agent on winter wheat and some researchers (Yang *et al*., 2011a) suggested that the application of 90 kg/hm$^2$ water retaining agent on wheat was the best treatment. In this experiment, the amount of 1 kg·667 m$^{-2}$ water retaining agent was the best treatment. This may be related to soil type, climatic conditions and wheat varieties and so on which needs further study.

The results showed that: under this experimental conditions, when the amount of water retaining agent was in range of 0-1 kg•667 m$^{-2}$, with the increase in the amount of water retaining agent, the chlorophyll content, net photosynthetic rate, stomatal conductance and transpiration rate of dryland wheat increased and intercellular $CO_2$ concentration decreased; when the amount of water retaining agent was in range of 1-2 kg•667 m$^{-2}$, with the increase in the amount of water retaining agent, chlorophyll content, net photosynthetic rate, stomatal conductance and transpiration rate of dryland wheat decreased, intercellular $CO_2$ concentration increased. Water-retaining agent will help improve drought resistance of dryland wheat to adjust dryland wheat photosynthetic characteristics and chlorophyll content. The application amount of 1 kg•667 m$^{-2}$ (T2) of water-retaining agent was the most conducive to the accumulation of photosynthetic products, so as to provide the conditions to obtain higher yield of wheat.

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