Effect of Reducing Fertilizer Application Models on Nutrient Use Efficiencies of Wheat in Rice-wheat Cropping System

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Abstract: In order to explore the effects of different reducing fertilizer application modes on nutrient use efficiency of wheat in rice-wheat cropping system to provide theoretical basis for achieving high efficient application of chemical fertilizer and its zero increase in China, this paper carried out 3 years field positioning experiment of rice-wheat cropping system. The experiment set 6 treatments including no fertilizer(T1), conventional chemical fertilization (T2), combined application of organic; manure and chemical fertilizer (T3), reducing 20% Chemical fertilizer plus increasing nitrogen fertilizer synergist application (T4), reducing 20% chemical phosphorus fertilizer long with phosphorus activator application (T5), and reducing 20% chemical nitrogen fertilizer and 20% Chemical phosphorus fertilizer along with nitrogen fertilizer synergist plus phosphorus activator application (T6). The results showed that T4 treatment was beneficial to enhance the nitrogen absorption capacity of wheat, improve the nitrogen absorption efficiency, enhance the nitrogen use efficiency, improve the potassium use efficiency; T5 treatment could significantly increase the total phosphorus uptake, phosphorus uptake efficiency, partial productivity and absorption efficiency of wheat. T6 treatment could significantly improve the nitrogen absorption capacity, phosphorus partial productivity and potassium use efficiency of wheat. T3 treatment had no significant effect on the absorption and utilization of nitrogen and phosphorus in wheat, and significantly reduced the partial productivity of potassium in wheat. In conclusion, theT6 treatment was beneficial to coordinate nutrient uptake and stabilize wheat yield. It could be a preference pattern for reducing fertilizer application and increasing efficiency in rice-wheat cropping system at the Middle and Lower Reaches of the Yangtze River and with similar ecological conditions.

1 INTRODUCTION

Fertilizer synergist is one of the effective means to reduce the amount of fertilizer and improve the utilization rate of fertilizer. In recent years, there have been reports on the application of different kinds of fertilizer synergist in corn (Wang 2015), cotton (Xu 2018), rice (Wu 2012) and other crops. Studies (He 2011) have shown that the application of fertilizer synergist can reduce the amount of fertilizer, simplify the method of fertilization, reduce the cost of fertilization, reduce chemical fertilizer pollution and protect the environment. Influenced by climatic conditions and soil fertility, the effect of reduced fertilization may vary regionally. This study carried out in Ezhou of Hubei province three-year positioning rice-wheat rotation reduction fertilization field experiment, the different modes of reduced fertilization on rice and wheat yield and nutrient absorption use, in order to provide theoretical and technical basis of rice-wheat rotation.

2 MATERIALS AND METHODS

2.1 Test Design

The experiment set 6 treatments including no fertilizer(T1), conventional chemical fertilization (T2), combined application of organic; manure and chemical fertilizer (T3), reducing 20% Chemical fertilizer plus increasing nitrogen fertilizer synergist

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application (T4), reducing 20% chemical phosphorus fertilizer along with phosphorus activator application (T5), and reducing 20% chemical nitrogen fertilizer and 20% Chemical phosphorus fertilizer along with nitrogen fertilizer synergist plus phosphorus activator application (T6) . Fertilization was shown in Table 1.

Table 1: Different fertilizer application models for rice-wheat cropping experiment (kg/hm^2).

Treatment	Chemical fertilizer(kg/hm^2)			Organic Fertilizer (kg/hm^2)	Nitrogen fertilizer synergist (kg/hm^2)	Phosphorus Activator (kg/hm^2)
	N	P_2O_5	K_2O			
T1	0.0	0.0	0.0	0	0	0
T2	180.0	105.0	120.0	0	0	0
T3	180.0	105.0	120.0	1500	0	0
T4	144.0	105.0	120.0	1500	1.67	0
T5	180.0	84.0	120.0	1500	0	225.0
T6	144.0	84.0	120.0	1500	1.67	225.0

2.2 Sample Collection and Analysis

The grain and straw samples were bagged and put into an oven and dried to a constant weight at 80℃, after crushing and sieving, use concentrated H_2SO_4-H_20_2 to discook. The content of nitrogen and phosphorus was determined by flow injection analyzer, and the content of potassium was determined by flame photometer (Bao 2000).

2.3 Computational Formula

Nutrient index calculation method (Wang 2017) is as follows:

Total uptake amount kg/hm^2= Sum of the dry weight of each organ x Nutrient content; Partial factor productivity kg/kg = Crop yield/ fertilizing amount; Uptake efficiency kg /kg = Total nutrient uptake/ fertilizing amount; Use efficiency kg/kg = Grain yield/total nutrient uptake.

3 RESULTS AND ANALYSIS

3.1 Effects of Different Fertilizer Application Models on Nitrogen Uptake and Utilization in Wheat

As can be seen from Figure1 and Figure2, in 2018, the total nitrogen uptake of T4 was significantly higher than that of other treatments, while the total nitrogen uptake of aboveground was also different among treatments T2, T3, T5 and T6. The total nitrogen uptake of T5 treatment was the highest in 2019 and 2020, which increased by 9.22% and 20.7% compared with T2, respectively. The total nitrogen uptake of T4 in 2020 was significantly higher than that of T2. In 2018 and 2020, the nitrogen absorption efficiency of T4 and T6 treatment was significantly higher than that of T2 treatment. In 2019, the nitrogen absorption efficiency of T5 and T6 treatment was significantly higher than that of T2 treatment. The nitrogen use efficiency and nitrogen partial productivity of T5 and T6 treatment were significantly higher than that of T2 treatment for 3 years. In 2018 and 2020, the N use efficiency and N partial productivity of T4 treatment were significantly higher than that of T2 treatment.

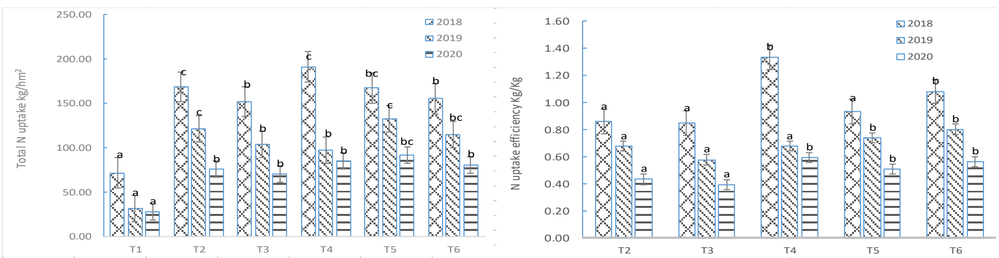

Figure 1: Effect of different treatments on nitrogen uptake and utilization of wheat in the three year at rice-wheat cropping system.

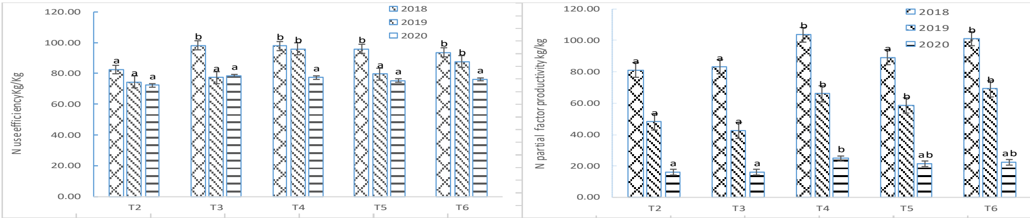

Figure 2: Effect of different treatments on nitrogen utilization of wheat in the three year at rice-wheat cropping system.

3.2 Effects of Different Fertilizer Application Models on Phosphorus Uptake and Utilization in Wheat

As can be seen from Figure3 and Figure4, compared with CK, fertilization (T2, T3, T4, T5, and T6) significantly increased the total phosphorus uptake from wheat shoots. In 2018, T4 treatment increased the total phosphorus uptake in wheat shoots by 11.75% compared with T2 treatment. In 2019, T5 and T6 treatments increased the total phosphorus uptake in wheat shoots significantly higher than T2 treatments. The phosphorus absorption efficiency of T5 treatment for 3 years was significantly higher than that of T2 treatment. In 2019, the phosphorus absorption efficiency of T6 treatment was also significantly higher than that of T2 treatment. In 2018 and 2019, the P partial productivity of T5 and T6 treatments was significantly higher than that of T2 treatment. In 2020, the P partial productivity of T6 treatment was also significantly higher than that of T2 treatment, and the P partial productivity of T5 treatment was 12.18% higher than that of T2 treatment.

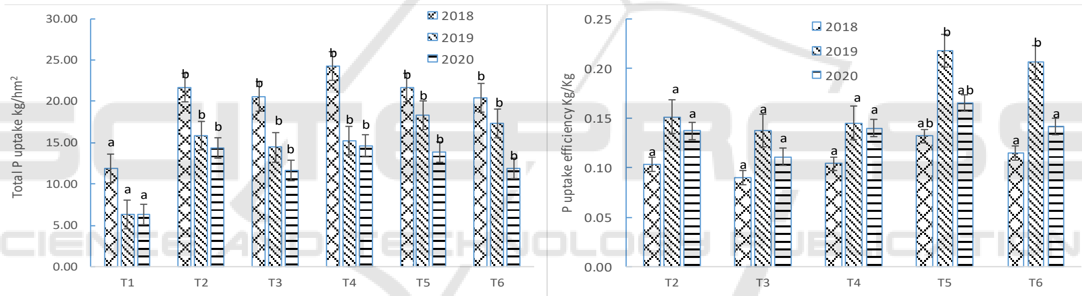

Figure 3: Effect of different treatments on phosphorus uptake and utilization of wheat in the three year at rice-wheat cropping system.

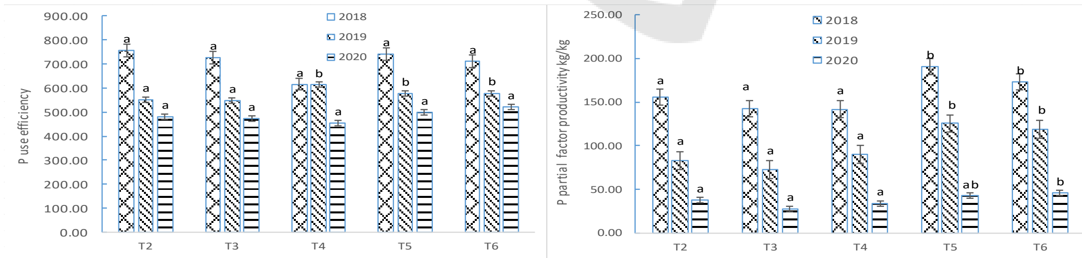

Figure 4: Effect of different treatments on phosphorus utilization of wheat in the three year at rice-wheat cropping system.

3.3 Effects of Different Fertilizer Application Models on Potassium Uptake and Utilization in Wheat

As can be seen from Figure5 and Figure6, the total uptake of potassium in the shoot of wheat in each fertilization treatment was significantly higher than that in the control treatment (T1). Total potassium uptake and uptake efficiency in T5 treatment was significantly higher than that in T2 treatment in 2018 and 2019. In 3 years, potassium utilization efficiency of T6 treatment was significantly higher than that of T2 treatment. In 2018, the potassium utilization efficiency of T4 treatment was significantly higher than that of T2 treatment. In 2019, the partial productivity of potassium in T6 treatment was significantly higher than that in T2 treatment. Compared with T2 treatment, T3 treatment significantly reduced the partial productivity of potassium in wheat.

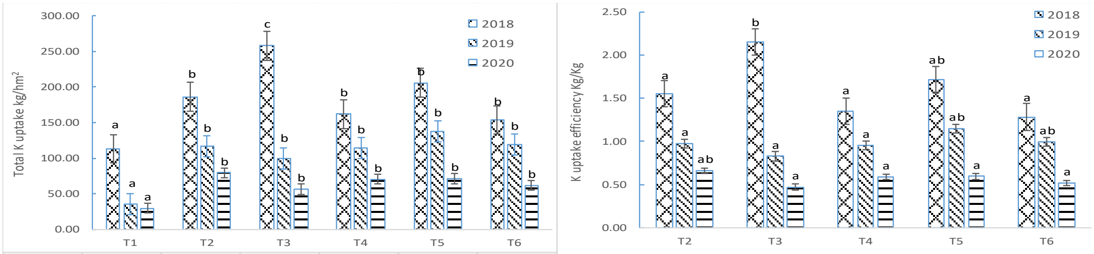

Figure 5 Effect of different treatments on potassium uptake and utilization of wheat in the three year at rice-wheat cropping system.

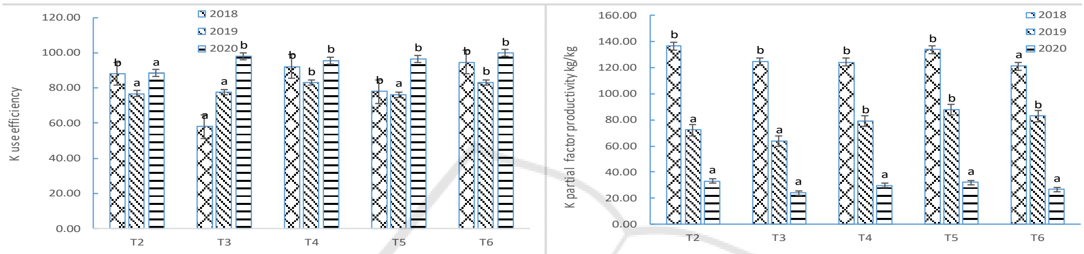

Figure 6: Effect of different treatments on potassium utilization of wheat in the three year at rice-wheat cropping system.

4 CONCLUSION AND DISCUSSION

Nutrient uptake is an important parameter to measure crop growth. Tian X Y (2006) found that the total amount of urea combined with nitrogen fertilizer synergist could significantly improve the agronomic efficiency, physiological efficiency and nitrogen use efficiency of nitrogen. Yi Q (2010) showed in his study that rice and wheat yield did not decrease under the treatment of 20%-30% nitrogen reduction, while nitrogen use efficiency, nitrogen agronomy use efficiency and nitrogen partial productivity increased in the current season. The results of this study showed that the reduced fertilizer treatment combined with nitrogen synergist was beneficial to enhance the nitrogen absorption capacity of wheat, improve the nitrogen absorption efficiency, and enhance the nitrogen utilization efficiency. The reason may be that fertilizer synergist can improve the utilization rate of fertilizer.

Phosphorus uptake and utilization by plants are affected by various factors. Some studies (Cai 2018, Zhan 2017) believed that Haoda fertilizer synergist could promote the absorption of nutrients by radish and Chinese cabbage, and improve the efficiency coefficient of nitrogen, phosphorus and potassium nutrients in radish and Chinese cabbage. The results showed that the reduced fertilizer treatment with phosphorus synergist could significantly increase the total phosphorus uptake, phosphorus uptake efficiency, phosphorus partial productivity and absorption efficiency of wheat. This is consistent with the previous research results of our research group (Liu 2018). The reason may be that the synergist can stimulate crop growth and promote nutrient absorption, reduce the degradation of phosphorus in the soil, enhance the growth of crop root system, and comprehensively regulate the absorption and utilization of nutrient elements in crops, so as to improve the utilization rate of fertilizer.

The crop demand for potassium is high (Liu 2006). Xu M (2018) showed that the synergist could promote the accumulation of nitrogen, phosphorus and potassium nutrients in the shoot of cotton plant and promote the utilization of nutrients in chemical fertilizers. The results of this study indicated that reduced fertilization combined with synergist could significantly improve K utilization efficiency and K partial productivity. This is consistent with the research results of others (Yang 2015). This may be the synergistic effect that leads to the improvement of phosphorus and potassium utilization.

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