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Research Article

The Effects of Different Amounts of Controlled Release Fertilizer on the Root Growth and the Filling Rate in Winter Wheat

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Abstract: In order to increase the fertilizer use efficiency and yield in winter wheat, the effects of controlled release fertilizer on the root growth and the filling rate in winter wheat by applying different amounts of controlled release fertilizer had been studied in open field. The results indicated that conventional complex fertilizer and controlled release fertilizer could cause corresponding changes of the wheat root activity, dry root weight, root-shoot ratio and filling rate, but the fertilizer of conventional fertilizer performed in the pre-stage significantly, controlled release fertilizer performed in the middle and late stage gradually. So mixing conventional fertilizer with controlled release fertilizer can ensure the nutrient supply of whole growth and development of wheat to explore the most appropriate collocation dosage. This will make fertilizer and economic benefits achieve the best.

Keywords: Controlled release fertilizer, dry root weight, filling rate, root activity, root-shoot ratio

INTRODUCTION

The growth and development of crop need nutrients supplying and fertilizer is one of the main ways to provide the necessary nutrients for the crop (Liping, 2010). Currently, the sort of fertilizer is numerous, such as various release fertilizer, complex fertilizer, nitrogenous fertilizer, phosphate fertilizer, potassic fertilizer and so on. Consequently, choosing what kind of fertilizer and the quantity of fertilizer are particularly important for promoting crop yield, fertilizer utilization and environmental protection (Xiaolin *et al*., 2009). The contradiction of China between population and land resources is increasingly prominent. Increasing crop yield is an important method to solve the contradiction. And exploring the fitting measures on application of fertilizer plays a considerable role for China's crop yield increasing. There have been some researches on the research status and prospect of our country's slow controlled release fertilizer (Bin and Weizheng, 2010).

With the characteristics of releasing nutrients slowly and the consistent pace of nutrients releasing and absorbing, controlled release fertilizer has the capability to provide nutrients demanded for the crop in growing peak periods. It is extremely significant to explore the characteristics of the controlled-release fertilizer for our country to study fertilizer (Zhu, 2012). As the important indicator, the performance of wheat root activity, dry weight, Root-shoot ratio and filling rate can reflect growth status well. The reasonable application of controlled release fertilizer can improve and enhance above items accordingly. Root activity reflects the capabilities of nutrients absorption and synthesis. Controlled release fertilizer can increase wheat root activity timely, namely being favorable to the absorption and synthesis of nutrient (Zhonghua and Shenglu, 2009). Dry root weight reflects the degree of nutrients accumulation and up-growth of root system. Rational application of controlled-release fertilizer plays a certain role on dry root weight increasing effectively. Root-shoot ratio links the underground with aboveground portion and reflects the growth and development of wheat on the whole. To some extent, controlled release fertilizer coordinate Root-shoot ratio to meet the production requirements. For winter wheat, filling rate is an important factor of grain formation and full degree (Hongxia *et al*., 2010). Controlled release fertilizer can improve the filling rate effectively and ensure the quality and yield certainly.

To some extent, scholars have studied the effect of controlled release fertilizer on crops (Shaohe *et al*., 2013; Guoqing *et al*., 2013; Dandan and Yan, 2013) presently. This study divided winter wheat into five groups and adopted different treatments, respectively. The group without controlled release fertilizer is the control group and the other four groups were treated with different amounts of controlled release fertilizer to measure wheat root activity, dry root weight, root-shoot ratio and filling rate at different growth stages. Compare the results and analyze the reasons for differences to provide a theoretical basis for the

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Table 1: Design of treatments (unit: kg/667 m^2)

Treatments	CK	T1	T2	T3	T4
CRF	0	100	66.7	50	33.3
CCF	100	0	0	50	33.3

application and popularizing of controlled release fertilizer in winter wheat.

MATERIALS AND METHODS

Experiment materials: The experiment material is the wheat variety "Jimai 22". The Controlled Release Fertilizer (CRF) of Aolindan label brand was produced by Kingenta's company and the Formula of N-P_2O_5-K_2O of the CRF was 22-8-12. The Conventional Complex Fertilizer (CCF) named label YAN NONG complex fertilizer which Formula was 22-8-12 was produced by the YAN-NONG-Weifang Agricultural Chain Co., Ltd.

Experiments design: The experiments have been carried on from June, 2012 to June, 2014 in the open field in the Qingdao Agricultural University (120.39°E, 36.32°N). The organic matter content of soil is 1.1%, total N 1.9%, available nitrogen 192 mg/kg, available phosphorus 42 mg/kg and potassium 185 mg/kg. The experiment set up 5 treatments and the quantity of fertilizers applied details showed in Table 1. Ditch to fertilize between the planting rows, mix the fertilizer uniformly and employ block design randomly in the field. The experiment design 3 repeats with each treatment and leave 0.50 m wide between repeats as observation road. Design 0.3 m district of which the area is 12*15 m as isolation region. Testing ground around locate the protected area. No additional fertilizer was applied during the growth period of wheat. Wheat was planted in the October, 2012 to keep consistently and the quantity of sowing is 12 kg • 667 m^{-2}.

Items: According to Table 1, apply different amounts of controlled release fertilizer to five treatments which are CK, T1, T2, T3 and T4. In all treatments, measured the root activity, dry root Weight, root-shoot ratio and filling rate at the important growth period such as 0, 7, 14, 21 and 28 days, respectively after anthesis and so on to explore the effects of controlled release fertilizer on the growth and development of wheat.

RESULTS

Effects of controlled release fertilizer on the root activity of winter wheat: We can see from the Fig. 1, the overall trend of wheat root activity decreased gradually. The root activity of 5 treatments changed differently in the different growth periods and performed differently in the same growing season too. Contrasting root activity of 0 days after anthesis, root activity is T3>T4>CK>T1>T2. Root activity of T3 is the greatest at 0, 7 and 14 days, respectively after anthesis. And root activity of CK is the smallest at

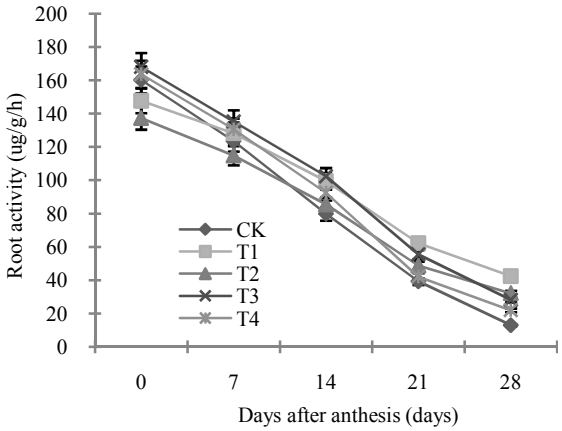

Fig. 1: Effects of different amounts of controlled release fertilizer on root activity in winter wheat

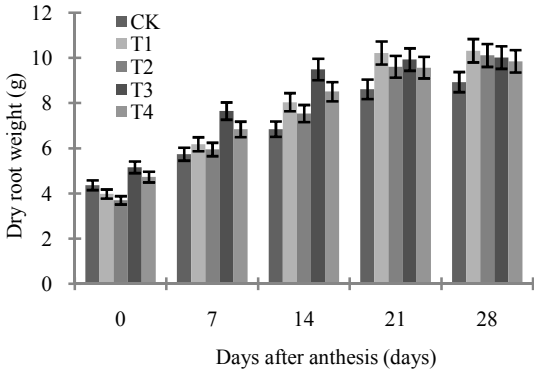

Fig. 2: Effects of different amounts of controlled release fertilizer on dry root weight in winter wheat

14, 21 and 28 days, respectively after anthesis. Root activity is T1>T2>T3>T4>CK at 28 days after anthesis. In all the treatments, root activity declined 91.92, 71.26, 76.61, 83.26 and 86.58%, respectively, namely amplitude of decreasing was CK>T4>T3>T2>T1.

Effects of controlled release fertilizer on the dry root weight of winter wheat: As was showed in Fig. 2, dry root weight of five treatments have an increasing trend with the date prolonged of wheat after anthesis, but the increasing extent was different. There are diversities among treatments on the specific performance though at the same period. We can see from the dry root weight of zero days after anthesis that T3 is heaviest, then T4, CK, T1 and T2 in succession. However 28 days after anthesis, dry root weight is T1>T2>T3>T4>CK. The changing extent of dry root weight of five treatments is different from 0 to 28 days after anthesis.

Effects of controlled release fertilizer on the root-shoot ratio of winter wheat: We can make it out from Table 2 that root-shoot ratio of winter wheat in all

Table 2: Effects of different amounts of controlled release fertilizer on root-shoot ratio of days after anthesis

Treatments	0	7	14	21	28
CK	0.103	0.119	0.110	0.097	0.093
T1	0.110	0.111	0.099	0.082	0.075
T2	0.116	0.114	0.100	0.084	0.080
T3	0.092	0.102	0.098	0.078	0.072
T4	0.095	0.109	0.100	0.083	0.079

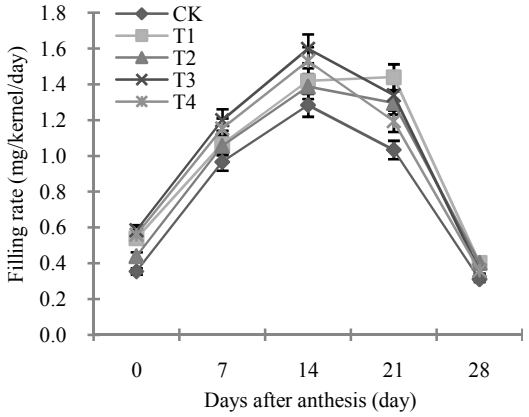

Fig. 3: Effects of different amounts of controlled realse fertilizer on filling rate in winter wheat

treatments were gradually decreasing. Root-shoot ratio of 0 days after anthesis is T2>T1>CK>T4>T3, but of 21 and 28 days after anthesis is CK>T2>T4>T1>T3. In addition, CK is the maximum and T3 is the minimum at 0, 14, 21 and 28 days, respectively after anthesis. Root-shoot ratio of five treatments declined 9.71, 31.82, 31.03, 21.74 and 16.84%, respectively, that is to say the decreasing extent of root-shoot ratio is T1>T2> T3>T4>CK.

Effects of controlled release fertilizer on the filling rate of winter wheat: We can find out from Fig. 3 that filling rate of winter wheat in all treatments performed to increase first and then decline gradually. No mater merely applying controlled release fertilizer or conventional complex fertilizer or combining controlled release fertilizer with conventional complex fertilizer, the overall trend of filling rate is identical. The filling rate of 0, 7 and 14 days, respectively after anthesis were all T3>T4>T1>T2>CK. Furthermore, there are some differences on the specific performance among five treatments in the same growing season. The filling rate of T1, T2, T3 and T4 were higher than that of the CK all the time. Moreover, the filling rate of T3 and T4 were higher than that of T1 and T2 before the filling rate decreasing.

DISCUSSION AND CONCLUSION

Impacted by soil, the quantity of nutrients and water absorbing and demanded will change during the wheat growth and development (Haiyan *et al*., 2013). So root activity, dry root weight, root-shoot ratio and filling rate is changing constantly. The changes of these indicators can reflect the growth and development of wheat well. Root activity reflects the capabilities of nutrients absorption and synthesis. The results indicate that, with the wheat matures, root activity will decrease gradually. The root activity of CK which is without controlled release fertilizer and with conventional complex fertilizer only decreased sharpest and T1 reduced least. On the one hand, the related substances of root may be changing, for instance the content of MDA increased, SOD and CAT decreased gradually. That will do damage to cells leading to a decrease in root activity (Chaohai and Daocheng, 2010). On the other hand, the CK getted an adequate nutrients supply to promote root activity in pre-period. Later it failed to meet the amount of nutrients needed for growing and root activity reduced rapidly. But T1 getted a certain amount of nutrients in the early stage and the root activity is not particularly small. Later T1 obtained nutrients needed for growth leading to root activity being relatively bigger. So root activity of T1 decreased little. Dry root weight reflects the degree of nutrients accumulation and up-growth of root system. Whether apply to controlled release fertilizer or not, dry root weight will increase in this experiment. But it does not mean that the bigger, the better. The dry root weight of T1 is the biggest and followed by T2, T3 and T4, though of CK is the lightest. The reason may be that the application of controlled-release fertilizer provided a more adequate nutrient for wheat growth and development at the middle-late stage. However dry root weight which is too large may well affect the growth and development of aboveground accordingly to cause reduction of output. Root-shoot ratio links the underground with aboveground portion and reflects the growth and development of wheat on the whole. Root-shoot ratio of late days being small is the precondition of wheat growing well (Longtao *et al*., 2011). In this experiment, Root-shoot ratio of T1, T2, T3 and T4 is bigger than CK at jointing and heading stage, yet smaller than CK at 21 days of flowering. To some extent, it states that the controlled release fertilizers coordinate the root-shoot ratio timely to make it be in line with the requirements of growth and development. For wheat, filling rate is an important factor of grain formation and full degree. Someone (Zhaojiang *et al*., 2010) has done the study of winter wheat on grain filling characteristics and simulation model under the situation of regulated deficit irrigation. The filling rate of T1, T2, T3 and T4 is always bigger than the CK in this experiment. The results show that controlled release fertilizer increases filling rate more effectively; of T3 and T4 is more higher than T1 and T2 before the filling rate decreasing to indicate that mixing controlled release fertilizer with conventional fertilizer is more better than applying controlled release fertilizer only;

however, of T3 increases greatest at early stage and decreases sharpest at late stage. It is to say T3 is more suitable for the growth of wheat than T4.

The results indicate that controlled release fertilizer plays a more advantageous role on the growth of wheat, namely T1, T2, T3 and T4 being better than CK; mixing controlled release fertilizer with conventional fertilizer is more better than applying controlled release fertilizer only, namely T3 and T4 being better than T1 and T2. Appropriate dosage of collocation is more favorable for the full utilization of fertilizer. T3 is better than T4, though T3 and T4 both mix controlled-release fertilizer with conventional fertilizer, namely T3 being the most suitable dosage of collocation for the wheat. Summing up five treatments on wheat root activity, root dry weight, root-shoot ratio and filling rate, controlled release fertilizer and conventional complex fertilizer both improve and enhance the above items accordingly. But the characteristics are different, respectively. The fertilizer of conventional fertilizer performed in the pre-stage significantly and controlled release fertilizer performed in the middle and late stage gradually. So mixing conventional fertilizer with controlled release fertilizer can ensure the nutrients supplying of whole growth and development of wheat to explore the most appropriate collocation dosage. This will make fertilizer and economic benefits achieve the best.

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