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Research Article

The Effects of Controlled Release Fertilizer and Conventional Complex Fertilizer on the Dry Matter Accumulation and the Yield in Winter Wheat

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Abstract: In order to research the use ratio of controlled release fertilizer in winter wheat. So, the experiment about the effects of Controlled Release Fertilizer (CRF) and Conventional Complex Fertilizer (CCF) on the dry matter accumulation and the grain yield in winter wheat has studied with pots in the open field. The results indicated that the CRF improved the proportion of the number of effective tillers to the total number of tillers. And the mixture of the CRF and equivalent CCF have more improved the proportion of the dry root weight to the total dry matters of the after of wheat flowering stage than that of the CRF used alone (T1, T2, T3). The treatment T6 was more improved the accumulation of the dry matters of aerial part than others. And the weight gain of T6 after a thesis was higher than other treatments and the control treatment (CK). In the facts of grain number per spike, thousand grain weight and yield, the treatments of the mixture of the CRF and equivalent CCF (T4,T5,T6) were higher than that of the treatments of CRF used only (T1,T2,T3) and CK, in which the T6 was highest. So, we think that this treatment namely T6 was used fertilizers least and gained the highest yield of grain.

Keywords: Controlled Release Fertilizers (CRF), Conventional Complex Fertilizer (CCF), the dry matter accumulation, wheat, yield

INTRODUCTION

The Controlled Release Fertilizers (CRF) are a high efficient use fertilizer which law of slowly dissolves the nutrients into the root zone is consistent with the nutrients required for plant growth. Many domestic studies have shown that the low fertilizer utilization in China (Zhu, 2000a; Li, 1999; Zhang *et al*., 2008), serious fertilizers wastage or loss (Qiong *et al*., 2012; Zhu, 2000b), large amounts of fertilizer were used in order to obtain a higher yield in agricultural production, especially nitrogen fertilizer application. So, this phenomenon caused those problems of serious loss of nitrogen fertilizer and environment pollution, such as the soil and the water. Therefore, how to reduce the quantity of using fertilizer, increasing fertilizer utilization in agricultural production became challenges to agricultural in China. Studies have shown that the CRF can improve the efficiency of using fertilizer effectively, reduce the damage to environment and ecology caused by using much fertilizer and the CRF are environment friendly with no pollution. So, the CRF can play a role in a huge loss of control of fertilizer (Wang, 2008). The growth of crop and dry matter accumulation have closely related to the type of fertilizers and the way of farming planting (Xiangyang *et al*., 2011; Guoqing and Yan, 2012). And the amount of applied fertilizer (Wang *et al*., 2006) and the law of fertilizer nutrient used in field soil to the dry matters of accumulation of wheat have particularly important effects in the yield of wheat.

For the features of slowly and continuously dissolves the nutrients of CRF (Song *et al*., 2005), so we set up this experiment by the pots in the open field in order to research the use ratio of controlled release fertilizer in winter wheat, so the effects of the CRF and the CCF on the wheat tillers, dry matters accumulation and the yield in winter wheat was studied by pots in the open field. We hope that the results of these experiments would provide the reference and theoretic basis in the farm production on aspect about reducing the application amount of nitrogen fertilizer by applied CRF and increasing the ratio of the use of fertilizer effectively.

MATERIALS AND METHODS

Experiment materials: The experiments have studied in 2011-2012 years by pots in the open field in the Qingdao Agricultural University (120.41°E, 36.10°N) with the wheat variety "Jiman 22" as the experiment material. The soil was sandy loam soil with soil organic matter content 11.09 g/kg, total N 1.01%, available nitrogen 84.12 mg/kg, available phosphorus 23.38

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Table 1: The quantity of different treatments (unit: g)

Treatment	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
∑	15	18	15	12	18	15	12

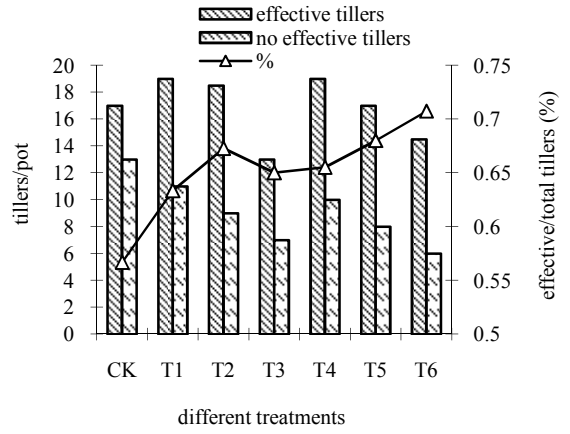

Fig. 1: The effect of the CRF on the tillers in winter wheat

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 Kingenta's company and the Formula of N-P2O5-K2O 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 experiment set up 7 treatments with each treatment 12 repeats, a total of 84 pots with 3 seedlings per pot. And planted in the October 15th, 2011. The quantity of fertilizers applied details showed in Table 1. Each pot which was diameter 30cm, depth 40 cm filled with air-dried sandy loam soil. The fertilizers were applied on the 10 cm-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 ensure that normal water was supplied for the wheat growing natural during the growing season of winter wheat and prevented the occurrence of pests and diseases of winter wheat.

Items: In May 7, May 16, May 22 and June 16 (harvest date) 2012, sampled 3 pots of each treatment at one time, then separated the roots, stems, leaves, leaf sheath, respectively and then dried them in the oven until constant weight to weigh, on the June 16 sampling the spike threshing weighed and calculated the grain weight. At last, the average of three pots as the result.

RESULTS

Winter wheat tillers number: We can see from the Fig. 1, the wheat tillers number was reduced with the reduction of the quantity of fertilizer, but the ratio of effective tillers number to the total number of tillers was increased with the reduction of fertilizer applied. This figure showed that the increase in fertilizer can increase the total number of wheat tillers, but cannot increase the ratio of effective tillers number to total tillers number. And we can see from the Fig. 1, the ratio of effective tillers number to the total number of tillers of treatments T4, T5, T6 were higher than that of the treatments T1, T2, T3 and CK. This showed that the ratio of effective tillers number of the mixture of the CRF and equivalent CCF treatments was higher than that of CCF used alone and the ratio of tillers of the treatments of add CRF was higher than that of CK treatment.

Dry Root weight of winter wheat: We can see from Table 2, the dry root weight have reductive trend with the date prolonged of wheat after a thesis. In all the treatments, the dry root weight of the T4, T5, T6 were higher than that of the T1, T2 and T3 before the May 22. And the proportion of the dry root weight to the total dry matter was gradually increased before May 22 and then had a downward trend. But for the T1, T2 and T3, the dry root weight and this proportion was not increased on May 22, but declined all the time. The root dry weight of T4, T5, T6 were greater than T1, T2 and T3 in the different periods of wheat growth. In the harvest period, the proportion of the dry root dry weight to the total dry weight was T6<T5<T1<T2<CK<T3 = T4. The decline the proportion of dry root weight maybe was more conducive to increase the dry matter of the aerial parts and provide a favorable material to ensure the improvement the yield of wheat. And we can see from the table, the proportion of dry root weight to the total matters of T6 on the May 22 period was higher than that of other treatments. We can think that in this period the treatment T6 can provide the nutrients and water for wheat growth and have an important role in increase the grouting of wheat, grain weight and grain yield. After the May 22, the harvest period the proportion of dry root weight to the total dry weight decreased, this showed that the material accumulation of the mature wheat was mainly transferred to the aerial parts before the period.

Dry matters of aerial parts accumulation: We can see from Table 3, the total grain weight was T6> T5>T4>T1>T2>T3>CK. For the same amount of fertilizers, the grain yield of the mixture of the CRF and equivalent CCF (T4,T5,T6) was greater than that of CRF used alone (T1,T2 ,T3) , the Grain yield of T1,T2, T3, T4,T5,T6 was greater than that of the CK treatment. From the dry weight of the aerial parts we

Table 2: The effect of the CRF on the dry root weight in the winter wheat

	7 May			16 May			22 May			16 June (harvest date)		
Treatments	Dry root weight	Total dry matter	Dry root/ total dry matter (%)	Dry root weight	Total dry matter	Dry root/total dry matter (%)	Dry root weight	Total dry matter	Dry root/total dry matter (%)	Dry root weight	Total dry matter	Dry root/total dry matter (%)
CK	1.38	16.71	0.083	3.39	46.35	0.073	4.29	45.18	0.095	1.59	42.77	0.037
T1	1.77	22.23	0.079	2.4	35.76	0.067	0.96	32.58	0.029	1.56	46.02	0.034
T2	2.76	12.48	0.223	1.99	28.31	0.070	2.07	35.87	0.058	1.52	43.60	0.035
T3	0.96	13.77	0.069	2.43	33.72	0.072	3.15	55.56	0.057	1.87	43.50	0.043
T4	4.77	34.77	0.137	1.83	25.62	0.071	2.52	35.71	0.071	2.08	48.51	0.043
T5	3.27	25.11	0.130	1.56	25.57	0.061	2.59	37.34	0.068	1.51	54.08	0.028
T6	2.37	15.63	0.151	1.08	22.56	0.047	2.67	38.40	0.069	1.39	59.92	0.023

Table 3: The effect of the CRF on the dry matters of aerial parts accumulation in winter wheat

		Dry matters of aerial parts				
Treatments	Grain yield	Dry matters after anthesis	Dry matters at harvest date	Increased weight	Increased weight/ dry matters at harvest date (%)	Harvest index
		15.33	41.18	25.85	62.7	0.447
T1	20.65	20.46	44.46	24.00	53.9	0.464
T2	18.79	9.75	42.08	32.33	76.8	0.447
T3	18.75	12.81	41.63	28.82	69.2	0.450
T4	20.98	30.00	46.43	16.43	35.4	0.452
T5	23.65	21.81	52.57	30.76	58.5	0.450
T6	27.89	13.26	58.53	45.27	77.3	0.477

Table 4: The effect of the CRF on the grain yield in winter wheat

Treatment	Spikes (pot)	Grain number per spike	Thousand grains weight (g)	Grain yield (pot)
CK	17	35.67	40.56	18.39cd
T1	19	36.98	41.95	20.65b
T2	18.5	36.51	42.89	18.79c
T3	13	35.82	43.87	18.75c
T4	19	37.14	43.56	20.98b
T5	17	38.51	45.49	23.65b
T6	14.5	39.85	47.14	27.89a

*Different letter means different significantly

can see that the proportion of the increased of dry weight after a thesis to harvest total dry weight was T6>T2>T3>CK>T5>T1>T4. The significantly increased of the dry matter weight of the aerial parts improve the promotion of grain of wheat. We can also see from the table, the size of harvest index of wheat was T6>T1>T4>T5 = T3>T2>CK. The minimum quantity of fertilizer applied was T6 and T1 and T4 were maximum, compared with the grain yield, the efficiency of fertilizer used of T6 was highest than that of other treatments and the CK. This showed that the T6 got the aim at the efficiently use ratio of fertilizers and higher grain yield of winter wheat.

Grain yield of wheat: We can see from Table 4, the trend of spikes was reducing with the reduced amount of fertilizer, because it may be related to the pre-fertilizer too much causing wheat growing too much. In face of grain number, the grain number of T1, T2, T3 (CRF used alone) reduced with the amount of fertilizer reduced. While the T4, T5, T6 (the mixture of the CRF and equivalent CCF) showed opposite trend. The thousand grains weight increased with the reduction of fertilizer, opposite to the wheat spikes trend. These maybes because increased of spikes have a negative impact on grain weight. We can see from the Table 4, the spikes number, grains, thousand grains weight and grain yield of T4,T5,T6 were higher than that of T1,T2,T3. This showed that the treatments of mixture of the CRF and equivalent CCF were higher than that of treatments of CRF used alone.

CONCLUSION

The rational applied and mixtures of fertilizers (Shi *et al*., 2001; Jingtian and Yan, 2012; Liyuan and Yan, 2012) played a key role in the growth and the yield of winter wheat. Most of studies have shown that the methods of fertilizer application in the open field soil and fertilizers types have a close relationship with the growth of wheat. These studies had confirmed that the fertilization depth (Shi *et al*., 2000) and increasing nitrogen fertilizers (Fu *et al*., 2000) had an impact on root growth and dry matters weight of wheat. In this experiment, the reasonable mixture of the CRF and equivalent CCF can significantly improved the number of tillers of wheat and can also increased the proportions of effective tillers. The proportion of controlling release fertilizer and conventional fertilizer was higher than other treatments and CK, which indicated that the CRF application increased wheat tiller number, reduced ineffective tillers, then decreased consumption and waste of fertilizer, providing fertility

for late growth of wheat and need of fertilizer. In the face of dry weight of wheat root, there was a reduce trend with the time extending after a thesis (Guoqing and Yan, 2012; Li and Shi, 2012), which has a relationship with the senescence of wheat. The dry root weight of the treatment of CRF was higher than that of treatment of CCF used alone and CK before harvested, but in the harvest time the root dry weight was lower than treatment CCF used alone and CK. It was indicated that the application of CRF can offer more nutrients for dry roots weight in the a thesis stage and grain filling stage in order to ensure the normal supply of adequate nutrients and water for wheat and the CRF can provide a reliable, accurate release of plant nutrients based on crop nutrient requirements. In harvest time of wheat, one reason was the aging of the root caused the root dry weight decreased, on the other hand, because the accumulation of matters transferring to the aerial parts, mainly in the wheat spike, which is in favour of getting more production for wheat. Studies have shown that nitrogen fertilizer can significantly increase the accumulation of substances (Cz, 2003). We can see from this experiment, after flowering, the dry matter of the aerial parts increased most significantly is T6, while the minimum fertilizer was T6. So the treatment T6 improved nitrogen efficiency of fertilizer and could reduce nutrient losses of volatilization, denitrification and leaching. The increased of dry matter of aerial parts promoted the grain yield increasing. In this experiment, the grains per spike, thousand grains weight and grain yield of the mixture of the CRF and equivalent CCF treatments were higher than that of treatments CRF used alone, with the T6 was the highest.

From all the results of this experiment, treatment T6 (the CRF and equivalent CCF was 6g, respectively) reached the maximum grain yield with minimum amount of fertilizer applied. So in this experiment, this treatment T6 can grain higher grain yield and achieve the high use of fertilizer effectively.

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