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EFFECTS OF NITROGEN APPLICATION LEVEL ON GROWTH AND YIELD OF WINTER WHEAT

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Keywords: Winter wheat, Nitrogen application level, Tiller number, Yield

Abstract

In order to achieve higher crop yield and improve the utilization efficiency of nitrogen fertilizer resources. Effect of nitrogen on the tillering ability, the aboveground dry matter mass and yield of winter wheat (WW) during the growing period were analyzed in a field experimental plot of Qinling Field Monitoring Center Station in Baoji City, Shaanxi Province from 2020 to 2021. Results demonstrated that nitrogen use significantly improved the tillering ability of WW during the overwintering and turning green stage; however, the use of nitrogen > 120 kg/hm^2 did not have a significant impact on the tillering ability of WW. The growth stages were directly proportional to the extent of aboveground dry matter accumulation (DMA) of WW and were found to be maximum at maturity. Greater usage of nitrogen significantly enhanced aboveground DMA before the jointing stage, but nitrogen application as high as 270 kg/hm^2 was not conducive to the aboveground DMA after the jointing stage. For WW, at first, the yield increased and then decreased with the increased concentration of nitrogen. When the nitrogen application level was 120 kg/hm^2, the highest yield of WW was 7506 kg/ha. However, there was an insignificant increase in yield at nitrogen levels > 120 kg/hm^2. In the study area, at nitrogen > 195 kg/hm^2, a decrease in yield was observed. Therefore, the recommended nitrogen application level in this area was 120kg/hm^2.

Introduction

Fertilization is an important means to increase agricultural production (Kresovic *et al.* 2016). Increasing nitrogen fertilizer application is of great significance in enhancing crop yield (Hu *et al.* 2013). Nitrogen is a vital parameter that regulates crop yield (Basso *et al.* 2010). Insufficient nitrogen will inhibit crop growth, resulting in lower yields. The impact of nitrogen fertilizer on crop yield has a critical effect (Zhang *et al.* 2016). Nitrogen application within an appropriate range is conducive to promoting yield improvement. Excessive nitrogen application may reduce yield, cause resource waste, and responsible for soil and groundwater pollution (Ziadi *et al.* 2012). Jia *et al.* (2014) reported that in China nitrogen fertilizer utilization rate is only 20 - 40% which is far lower than the world's average nitrogen fertilizer utilization rate. A large amount of nitrogen fertilizer input not only reduces the efficiency of nitrogen fertilizer use but also causes nitrogen that cannot be absorbed by crops to accumulate in the soil in the form of nitrate nitrogen, resulting in nitrate-nitrogen leaching and environmental pollution (Pellerin *et al.* 2000). Therefore, a suitable nitrogen fertilizer application rate is necessary to enhance yield and fertilizer use efficiency and minimize environmental pollution.

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Wheat is one of the main staple crops in China. Fertilization constitutes a basic measure to enhance wheat yield. The use of nitrogen fertilizer for the growth of wheat is an important factor that impacts the yield, but excessive long-term application of nitrogen fertilizer will cause waste of resources and environmental pollution, especially the leaching of nitrate-nitrogen (NO_3-N) will pollute groundwater sources and induce various diseases. Therefore, the appropriate amount of fertilization can not only ensure the nutritional needs of wheat growth but also prevent the plants from growing too long so that the potential of wheat yield can be maximized. Under the premise of achieving high quality and high yield of wheat, application of accurate concentration of fertilizer and improvement of nitrogen utilization efficiency is the key problem to be solved in this study.

Thus, this study was aimed to investigate effects of nitrogen on the tillering ability, above-ground DMA, and Winter wheat (WW) yield and also the optimal application rate of nitrogen fertilizer was analyzed via a field experiment. The results would provide a theoretical and technical basis to achieve the goal of efficient fertilization and enhancement of nitrogen use efficiency of WW.

Materials and Methods

The experiments were conducted at the Qinling Field Monitoring Center Station in Baoji City, Shaanxi Province. The altitude of the area was between 442-3767m and the average precipitation, the average relative humidity, the average sunshine, the average annual temperature was 609.5 mm, 7l%, 2015.2h and 12.9°C, respectively, and the light and heat were sufficient. The soil for the test is loess soil, and the test period was the wheat growing season, 2020-2021. The soil nutrient status of 0-20cm soil before sowing of WW was 12.47g/kg organic matter, 0.97 g/kg total nitrogen, 352 g/kg total phosphorus, 30.56 mg/kg alkaline hydrolyzed nitrogen, 29.75 mg/kg available phosphorus, and 129mg/kg available potassium.

A randomized block design was used for the experiment, and four nitrogen treatments were set N0 (no N applied), N120 (N 120 kg/hm^2 applied), N195 (N applied 195 kg/hm^2), and N270 (N 270 kg/hm^2 applied). Each treatment was repeated thrice, with a total of 12 field plots, each with an area of 6.5 m×5.5 m = 33 m^2. Nitrogen fertilizer was applied twice; 60% of the total amount of wheat was applied at the bottom, and the remaining 40% was used during the jointing stage and was applied in the furrows. The application rates of phosphorus and potassium fertilizers were: 120 and 75 kg/hm^2, respectively. Calcium superphosphate with a P_2O_5 content of 12%, and potassium sulfate with a K_2O content of 50% were used as phosphorus and potassium fertilizer, respectively. These two fertilizers were uniformly spread before wheat sowing and ploughed the land. The experimental variety of WW was Zhongxinmai 998, which was sown on September 28, 2020, and harvested on June 3, 2021. Except for the experimental treatment, other management measures were the same as those of general field cultivation.

The tillering ability of WW was measured during its overwintering and turning green stages. At the overwintering stage, turning green stages, jointing stage, flowering stage, and maturity stage of WW, aerial plant samples were collected, respectively. All samples were fastened for 30 min at 105°C, dried to constant weight at 80°C, and weighed as dry matter. At the maturity stage of WW, 1m^2 plots were selected in each plot for yield measurement.

Data analysis was done via Microsoft excel 2010, ANOVA was done using SPSS 22.0; LSD method was used to determine significant differences ($P < 0.05$). Origin 2018 was used to prepare the graphs.

Results and Discussion

Figure 1 showed that in the overwintering period and the greening period, the enhanced rate of nitrogen application was directly proportional to the tillering ability of WW, i.e., N270 > N195 > N120 > N0, and the tillering ability of WW under N120, N195, and N270 treatments was substantially higher than that of N0 ($P < 0.05$), that is, the tillering ability of WW under nitrogen application was substantially higher than that in no nitrogen application, $P< 0.05$, (Fig. 1).This indicated that to enhance the tillering ability of WW, the nitrogen application rate should be increased. However, there were no significant differences among N120, N195, and N270, indicating that nitrogen application could significantly improve the tillering ability of WW during overwintering and greening periods, but further enhancement in nitrogen application rate had no significant effect on improving tillering ability.

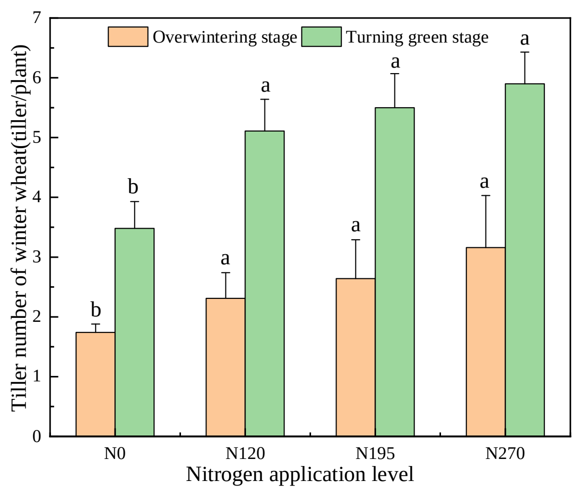

Fig. 1.Tiller number of WW under different nitrogen application levels. *Small letters indicate the significance under different nitrogen application rates at the 0.05 level between treatments.

Under the conditions of different nitrogen fertilizer application rates, the dry matter accumulation in the shoots of WW enhanced during the later stages of the growth period and reached the maximum during the mature period (Fig. 2). In the overwintering period, the greening period, and the jointing period, the DMA in the shoots increased with an increase in nitrogen application, and the difference was significant ($P < 0.05$) for N270, N195 > N120 > N0. During the flowering and mature stages, the DMA in the shoots showed enhancement followed by a decrease, with the increasing concentration of in nitrogen. The nitrogen application rate of N195 reached the maximum value, and N120, N195, and N270 could substantially enhance DMA in the shoots before jointing, but the nitrogen application was as high as 270kg/hm^2 was not conducive to DMA in the shoots after jointing. This finding is more or less similar result reported by Paolo *et al.* (2008).

Under different nitrogen application rates, the WW yield was increased initially, followed by a decrease with an increase in nitrogen application rate, i.e., N120 > N195 > N270 > N0, and the nitrogen application rates of N120, N195, and N270 were significantly higher than that of N0 ($P < 0.05$), but N120, N195 and N270 did not differ substantially (Fig. 3). At the nitrogen application rate of 120 kg/hm^2, the highest yield of WW was 7506 kg/ha. This indicated that nitrogen could substantially enhance WW yield ($P < 0.05$), but the further increase did not substantially impact the yield. In the study area, when nitrogen application exceeded 195 kg/hm^2, it lead to a yield decline. This conformed to the results of previous research suggesting that nitrogen fertilizer had a critical effect on yield, and nitrogen application within an appropriate range effectively increased the crop yield, while nitrogen fertilizer application beyond the appropriate range inhibited the yield (Fang *et al*. 2006, Fois *et al*. 2009).

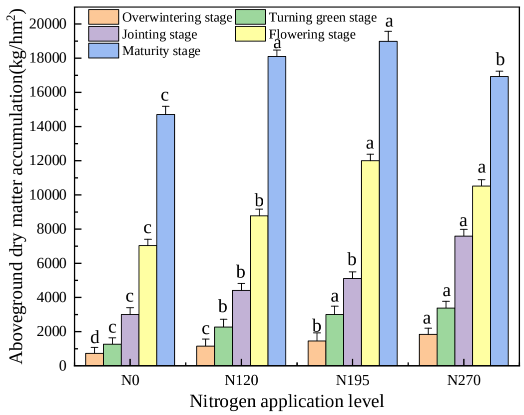

Fig. 2. The aboveground DMA of WW at different growth stages under different nitrogen application levels. *Small letters indicate the significance under different nitrogen application rates at the 0.05 level between treatments.

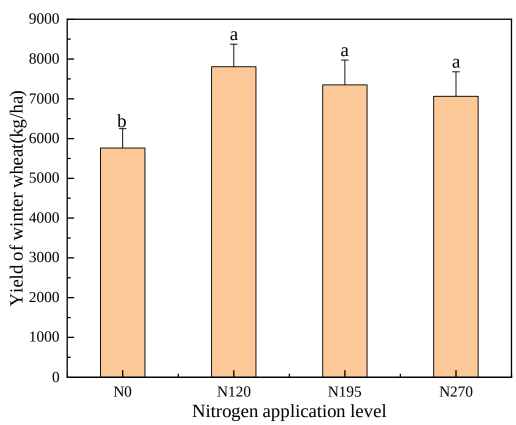

Fig. 3. The yield of WW under different nitrogen application levels.

*Small letters indicate the significance under different nitrogen application rates at the 0.05 level between treatments.

From the results obtained in the presented study it may be concluded that under the four nitrogen application levels, (a) nitrogen application could significantly improve the tillering ability of WW during overwintering and greening periods, but when the nitrogen application rate exceeded 120kg/hm^2, the effect on the tillering ability of WW was not significant.(b) The DMA in the shoots of WW increased during the later stages of the growth period and reached the maximum in the mature period due to the application of different nitrogen level. Higher use of nitrogen significantly enhanced the DMA in the shoots before jointing, but the nitrogen application as high as 270kg/hm^2 is not conducive to DMA in the shoots after jointing. (c) With an increase in nitrogen concentration, there was an initial increase in WW yield, followed by a decrease with an increase in nitrogen application rate. When the nitrogen application rate was 120kg/hm^2, the highest WW yield was 7506kg/ha. However, any further enhancement in nitrogen application rate did not significantly improve the yield, and when the nitrogen application rate exceeded 195kg/hm^2, it would lead to a decrease in yield. Therefore, considering comprehensively, the nitrogen application rate in the experimental area should be 120kg/hm^2. This study could provide a technical reference for the nitrogen application level for WW planting in loess soil in the Meixian area of Baoji City, Shaanxi Province.

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