Effects of Slow-release Nitrogen on Dry Matter Accumulation, Translocation and Yield of Summer Maize

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Abstract [**Objectives**] This study was conducted to investigate the effects of slow-release nitrogen fertilizer on dry matter accumulation and translocation of summer maize. [**Methods**] With Zhoudan 9 as the test variety, six different treatment were set up: blank control (CK1), slow-release urea 75 kg/hm^2 (C1), slow-release urea 150 kg/hm^2 (C2), slow-release urea 225 kg/hm^2 (C3), slow-release urea 300 kg/hm^2 (C4) and ordinary urea 300 kg/hm^2 (CK2), to study the change law of dry matter accumulation and translocation in summer maize. [**Results**] Treatment slow-release urea 225 kg/hm^2 (C4) showed summer maize yield, dry matter translocation between organs, grain contribution rate and proportion of grain dry matter in the full ripe stage higher than other treatments. Considering the weight loss and cost factors, slow-release urea 225 kg/hm^2 (C3) could be recommended as the fertilizing amount for summer maize. [**Conclusions**] This study provides theoretical reference for rational selection of fertilizers for reducing fertilizer application and increasing fertilizer efficiency, and for production of summer maize in Shajiang black soil region.

Key words Slow-release nitrogen fertilizer; Summer maize; Dry matter accumulation; Translocation
DOI: 10.19759/j.cnki.2164 – 4993.2024.03.004

In recent years, with the rapid development of animal husbandry and maize deep processing industry, China's maize consumption has increased strongly. It is predicted that the gap between maize production and demand in China will be 10 million to 20 million t in 2020[1]. Currently, the contradiction between high maize yield and high water and fertilizer efficiency in China is more prominent[2–3]. Scholars at home and abroad have done a lot of research on the relationship between fertilization and dry matter accumulation characteristics of maize. Dordas and Lu *et al.*[4–5] pointed out that common nitrogen fertilizer has the characteristics of quick solubility, which leads to the imbalance of nitrogen supply in the early and late stages of maize. Meanwhile, Ding *et al.*[6] found that slow-release nitrogen fertilizer improved the temporal and spatial consistency between soil nitrogen supply and nitrogen demand of crops during the whole growth period compared with ordinary urea. At present, there are few reports on the effects of slow-release nitrogen fertilizer on the growth and development of summer maize. In this study, sulfur-coated urea and ordinary urea were used as test fertilizers to study the effects of application rate of slow-release urea on dry matter accumulation and translocation in summer maize organs, so as to provide theoretical reference for rational selection of fertilizers for reducing fertilizer application and increasing fertilizer efficiency, and for production of summer maize in Shajiang black soil region.

Materials and Methods

Natural survey of the experimental site

The experiment was carried out in the experimental base of Zhoukou Academy of Agricultural Sciences (33° 37′ 39″ N, 114°47′40″ E). The experimental area has a typical temperate monsoon climate, with a frost-free period of about 150 d and an annual active accumulated temperature of about 3 200 ℃ · d. The soil is Shajiang black soil. The 0 – 30 cm soil layer contained 18.3 g/kg of organic matter, 37.23 mg/kg of available nitrogen, 68.0 mg/kg of available phosphorus and 196.9 mg/kg of available potassium. The experimental field had good irrigation conditions.

Experimental materials and design

The tested variety was Zhoudan 9. The planting density was 60 000 plants/hm^2, and the row spacing was equal. Each plot had an area of 20 m^2. The experiment adopted completely random arrangement, and was done in three replicates. There were six treatments in the experiment: no fertilization (CK1), slow-release urea 75 kg/hm^2 (C1), slow-release urea 150 kg/hm^2 (C2), slow-release urea 225 kg/hm^2 (C3), slow-release urea 300 kg/hm^2 (C4) and ordinary urea 300 kg/hm^2 (CK2).

Determination items and methods

In the spinning stage (VT), milk ripe stage (R3) and full ripe stage (R6) of maize, five representative plants were selected from each plot, and the organs were separated according to four parts: stem sheath (stem, leaf sheath, tassel), leaf, ear (cob, bract leaf, ear stalk) and seed, and they were put in an oven for 4 h of inactivation at 105 ℃, and then dried at 60 ℃ to constant weight. The dry matter weights were measured.

Data processing and statistical analysis

Excel was used for data processing, and dps 9.0 software was used for statistical analysis.

Results and Analysis

Dynamic changes of dry matter accumulation in various organs

Biological yield was the basis of economic yield. Fig. 1

Received: February 2, 2024 Accepted: April 5, 2024
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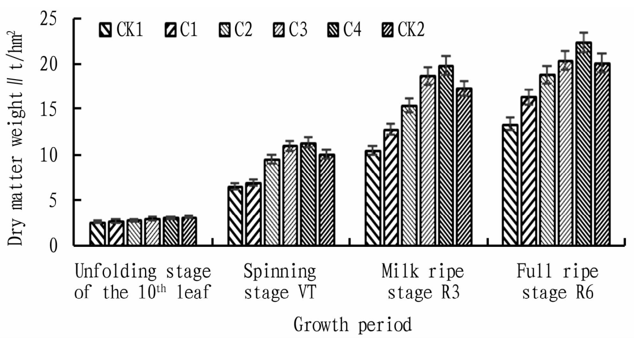
shows that there were no obvious differences among treatments during the unfolding stage of the 10^{th} leaf, but the total dry matter accumulation of each treatment showed a trend of increasing at first and then decreasing slightly from the spinning stage to the mature stage. In the range of 0 – 300 kg/hm^2, the amount of slow-release nitrogen fertilizer was positively correlated with dry matter accumulation, which showed an order of CK1 < C1 < C2 < C3 < C4. Meanwhile, when comparing the same amount of slow-release urea and ordinary urea, the dry matter accumulation with slow-release urea in each growth stage was greater than that of summer maize treated with the same amount of ordinary urea.



The ear part represents cob and husk leaves.

Fig. 1 Dry matter accumulation of summer maize

Comparison of dry matter translocation in different organs

As can be seen from Fig. 2, the amounts of dry matter translocation between organs were as follows: stem sheath > leaf. However, in the range of 0 – 300 kg/hm^2, the dry matter translocation of stem sheaths among slow-release urea treatments showed that C3 and C4 were basically the same, and they were all larger than CK1, C1 and C2, with significant differences, and the differences from other treatments all reached the significant level. The amount of dry matter translocation in leaves was the largest with C3, which was significantly different from other treatments. Meanwhile, when comparing the same amount of slow-release urea and ordinary urea, slow-release urea showed more dry matter translocation in both stem sheaths and leaves than ordinary urea, which showed that the same amount of slow-release urea was more conducive to the translocation of dry matter to grains and high yield in the later stage.

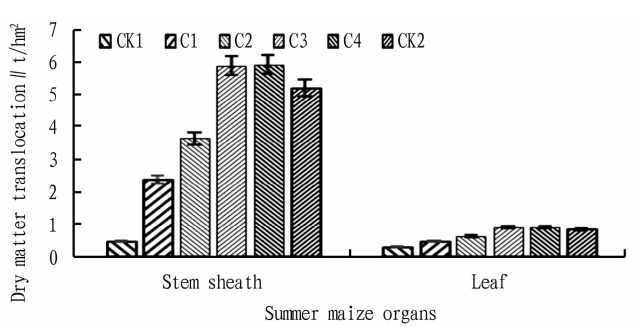


Fig. 2 Dry matter translocation of summer maize organs

Comparison of summer maize yield under different fertilizers and application rates

As shown in Table 1, the order of yield among slow-release nitrogen fertilizer treatments as C3 > C4 > C2 > C1 > CK2, in which the yield of C3 was highest at 8 015.52 kg/hm^2, higher than that of the control, and the yield of C4 took the second place with a value of 7 516.59 kg/hm^2. Meanwhile, compared with the blank control, all fertilization treatments had different degrees of yield increase, and the yield differences among treatments were significant. C3 and C4 showed the largest number of rows per ear, and there was no significant difference between them, but they were significantly different from other treatments. Meanwhile, C3 exhibited the largest number of grains per ear, which was different from other treatments. Under the condition of applying the same amount of slow-release urea and ordinary urea, the yield difference was significant, while the difference in rows per ear was not significant, which showed that the amount of nitrogen fertilizer in a certain range was positively related to yield, and applying the same amount of slow-release nitrogen fertilizer was more conducive to the formation of yield traits than ordinary urea, and more conducive to high yield.

Table 1 Effects of different fertilization treatments on maize yield

Treatment	Row number // rows	Grain number // grains	Yield // kg/hm^2
CK1	12.98 d	22.03 f	3 792.91 f
C1	13.87 c	25.96 e	4 358.72 e
C2	14.55 b	31.86 d	5 540.68 d
C3	15.34 a	36.58 a	8 015.52 a
C4	15.05 ab	35.01 b	7 516.59 b
CK2	14.59 b	34.48 c	7 283.35 c

Different lowercase letters following data indicate that difference in the same index between treatments reaches the 0.05 significant level.

Conclusions and Discussion

Higher biological yield is the material basis for high yield in maize production[7]. Different nitrogen fertilizers have different effects on dry matter accumulation during maize growth period. Huang *et al.* [8] found that slow-release nitrogen fertilizer had the characteristics of controlled-release and slow-release fertilizer efficiency, which could promote the translocation of nutrients to grains in the middle and late stage of maize growth, thus increasing the accumulation of dry matter. Wang *et al.* [9 – 10] think that the application of slow-release nitrogen fertilizer could better coordinate nutrient supply and improve the nitrogen absorption capacity of maize in the late growth stage, and the yield of slow-release fertilizer increased by 5.1% – 19.6% compared with conventional fertilization with the same nutrient amount. In this study, in the range of 0 – 300 kg/hm^2 of slow-release urea, the dry matter accumulation and translocation increased with the increase of nitrogen application rate, and after applying the same amount of slow-release urea and ordinary urea, the dry matter accumulation and translocation were higher than those of ordinary urea treatment. The application of slow-release urea in a certain amount can adjust the suitable nitrogen supply in the whole growth period of summer maize, and ensure the production performance in the middle and late growth period, thereby ensuring the yield-increasing physiological basis of dry matter accumulation and translocation. If the nitrogen supply exceeds a certain amount, the nitrogen supply will be excessive in the late growth period, resulting in remaining green when it should become yellow and ripe, and fertilizer waste and environmental pollution.

Considering the current market price and cost-saving space, 225 kg/hm^2 of slow-release urea could be used as a suitable fertilization model for summer maize, which has important theoretical and practical guiding significance to saving cost and increasing efficiency in summer maize cultivation in the soil area.

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Editor: Yingzhi GUANG Proofreader: Xinxiu ZHU

(Continued from page 7)

In particular, if there is strong wind or frost before harvesting, the fruit stalk will wither and become brittle after freezing, and a large number of seeds will fall off. Therefore, the weather forecast before harvesting should be closely monitored, and harvest the seeds in a rush if there is strong wind or frost.

Seed quality inspection

It is required to invite the seed inspection department to reexamine the produced seeds. The seeds of Pintianqiao 3 which meet the standards and have a certificate of conformity are labeled inside and outside the package.

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Editor: Yingzhi GUANG Proofreader: Xinxiu ZHU