Effect of Nitrogen Topdressing on Growth and Yield of Garlic

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Abstract With Cangshan garlic and early bolting garlic as experimental materials, this paper studies the effect of nitrogen topdressing on the garlic growth and yield of garlic stems and garlic bulbs. The results show that under the same amount of nitrogen, applying ammonium phosphor nitrate can better promote the growth of garlic than applying urea and ammonium chloride; both ammonium chloride and ammonium phosphor nitrate can effectively improve the yield of garlic stems and garlic bulbs, especially for ammonium phosphor nitrate; through economic benefit analysis, applying ammonium chloride and ammonium phosphor nitrate can produce greater economic benefits than applying urea, and especially ammonium phosphor nitrate increases the economic benefits of Cangshan garlic and early bolting garlic by 5490 yuan and 6690 yuan per ha, respectively.

Key words Topdressing, Nitrogen fertilizer, Garlic growth, Yield

1 Introduction

The period of garlic seedling establishment is the transition period from non-growth state of garlic under winter low temperature to gradual thriving. The garlic seedling growth rate and quality at this stage have a direct impact on the later growth and yield of garlic stems and garlic bulbs. At the early stage of garlic growth, the main source of nutrients is from garlic shoot and some soil nutrients. Garlic's demand for nutrients is mainly in the period of seedling establishment or after. The supply of nutrients, especially nitrogen in the period of seedling establishment, has an important impact on the late garlic growth. Different forms of nitrogen have different effects on crop growth. A number of scholars use water culture method to study the effect of different forms of nitrogen on the roots of rice, wheat, corn, soybeans and other crops at the seedling growth stage[1-3], and the results show that ammonium nitrogen and nitrate nitrogen have significantly different effects on roots, that is, ammonium nitrogen makes the roots become significantly short and thick, while nitrate nitrogen increases the root length and lateral roots[4]. Obviously, the form of nitrogen can change the form of crop root, and affect the crop absorption. By studying the effect of nitrogen on crop growth, we can determine the best form of nitrogen suitable for crop growth and the optimum nitrogen fertilizer ratio to improve yield and quality. In this study, with two different varieties of garlic as experimental materials, by applying different forms of nitrogen fertilizer, we systematically explore the response of garlic to different forms nitrogen fertilizer, with a view to provide the experimental basis for nitrogen topdressing on garlic.

2 Materials and methods

2.1 Overview of the experimental site The experiment was carried out in Youzhuang Village, Luzuo Town, Cangshan County, from September 2014 to May 2015. The soil is Shajiang black soil, with high and even fertility, and there are good irrigation conditions. pH value of 0 - 20 cm soil is 6.5; average organic matter content is 16.8 g/kg^{-1}; total nitrogen content is 1.29 g/kg^{-1}; alkali-hydrolyzable nitrogen content is 98.34 mg/kg^{-1}; available phosphorus content is 27.4 mg/kg^{-1}; available potassium content is 116.11 mg/kg^{-1}.

2.2 Experimental design The experiment selects two cultivars with different production purposes: the first one is early bolting garlic, with early sprouting and high yield of garlic stems, and the garlic sprouts produced are mainly supplied for early spring markets; the second one is Cangshan garlic, with high yield of garlic stems and garlic bulbs. The early bolting garlic was sown on September 29, 2014, with seeding rate of 675000 plants per ha; Cangshan garlic was sown on October 3, 2014, with seeding rate of 600000 plants per ha. The same amount of same base fertilizer was applied before sowing, namely 15 - 15 - 15 1500 kg/ha^{-1} potassium sulfate compound fertilizer, and 1200 kg/ha^{-1} FA - K organic fertilizer. Other cultivation and management measures are also consistent. During the first time watering (around April 5), three different nitrogen topdressing treatments were set for each variety of garlic, namely T_1 urea (300 kg/ha^{-1}, N = 138 kg/ha^{-1}); T_2 ammonium chloride (575 kg/ha^{-1}, N = 9.2 kg/ha^{-1}); T_3 ammonium phosphate (431.25 kg/ha^{-1}, N = 9.2 kg/ha^{-1}). 330 m^2 of plot was set for each treatment, and replicate was no longer set. On April 15, plant height and stem diameter were determined; on April 30, garlic stems of early bolting garlic were harvested; on May 6, garlic stems of Cangshan garlic were harvested; on May 16, garlic bulbs of early bolting garlic were harvested; on May 22, garlic bulbs of Cangshan garlic were harvested.

2.3 Sample collection and determination After 10 days of topdressing, the plant height and stem diameter of 20 garlic plants were continuously determined under each treatment. The plant height was measured with a meter stick, from the ground to the highest point of plant; the stem diameter was measured with cali-

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per, according to the thickest part above the ground. During the harvesting of garlic stems, 2.5 m × 1 m plot was selected under each treatment, to measure garlic stem yield, and each treatment was repeated three times; during the harvesting of garlic bulbs, 60 garlic plants were continuously chosen under each treatment, to measure garlic bulb yield, and each treatment was repeated three times.

2.4 Data processing Microsoft Excel 2010 is used to analyze experimental data and draw diagram, and SPSS18 is used to perform significant difference test on data (Duncan SSR method, $\alpha = 0.05$).

3 Results and analysis

3.1 Effect of different forms of nitrogen fertilizer on garlic plant height and stem diameter As can be seen from Table 1, after 10 days of different nitrogen topdressing, there are differences in plant height and stem diameter between two kinds of garlic. For early bolting garlic, the garlic plant height is greatest under T_3, significantly higher than under T_1, an increase of 5.2%; the garlic plant height under T_2 is also greater than under T_1, but the difference is not significant. There are no significant differences in stem diameter among the three treatments, but the stem diameter is in the order of $T_3 > T_2 > T_1$. For Cangshan garlic, the garlic plant height under T_3 and T_2 is significantly higher than under T_1, an increase of 10.8% and 6.1%, respectively; the difference is not significant between T_3 and T_2, but the plant height is in the order of $T_3 > T_2$. There are no significant differences in stem diameter among the three treatments, but the stem diameter is in the order of $T_3 > T_2 > T_1$. This shows that under the same climatic conditions, the nitrogen supply for garlic under T_3 is significantly faster than under T_1 and T_2, and the supply under T_2 is also faster than under T_1.

Table 1 Effect of different treatments on plant height and stem diameter of different garlic varieties

Variety	Treatment	Plant height cm	Plant height increase compared with T_1//%	Stem diameter mm	Stem diameter increase compared with T_1//%
Early bolting garlic	T_1	78.1 ± 1.2b	–	15.2 ± 1.4a	–
	T_2	80.5 ± 1.2ab	3.0	15.3 ± 1.6a	0.4
	T_3	82.2 ± 1.8a	5.2	15.5 ± 1.8a	1.8
Cangshan garlic	T_1	65.3 ± 0.8b	–	13.5 ± 1.6a	–
	T_2	69.3 ± 1.3a	6.1	13.6 ± 1.4a	0.2
	T_3	70.7 ± 2.4a	10.8	14.1 ± 0.6a	4.4

Note: Different letters represent differences between different treatments of the same garlic variety, the same below.

3.2 Effect of different forms of nitrogen fertilizer on yield of garlic stems and garlic bulbs As can be seen from Table 2, different nitrogen topdressing has significant effect on garlic yield. As for early bolting garlic, the yield of garlic stems under T_3 is 10.5% significantly higher than under T_1; the yield of garlic stems under T_2 also tends to be higher than under T_1, but the difference is not significant; there is no significant difference in the yield of garlic stems among the three treatments, but it is in the order of $T_3 > T_2 > T_1$. As for Cangshan garlic, the yield of garlic stems under T_3 is 9.1% significantly higher than under T_1; the yield of garlic stems under T_2 also tends to be higher than under T_1, but the difference is not significant; the yield of garlic bulbs under T_2 and T_3 is significantly higher than under T_1, an increase of 5.7% and 6.5%, respectively, compared with T_1.

Table 2 Effect of different treatments on the yield of garlic stems and garlic bulbs of different garlic varieties

Variety	Treatment	Yield of garlic stems g/667 m^2	Yield increase compared with T_1//%	Yield of garlic bulbs kg/667 m^2	Yield increase compared with T_1//%
Early bolting garlic	T_1	13417.5 ± 510b	–	14122.5 ± 307.5a	–
	T_2	13891.5 ± 565.5ab	3.5	14442 ± 316.5a	2.3
	T_3	14821.5 ± 475.5a	10.5	14737.5 ± 325.5a	4.4
Cangshan garlic	T_1	7602 ± 276b	–	22737 ± 474b	–
	T_2	7747.5 ± 261ab	1.9	24031.5 ± 228a	5.7
	T_3	8293.5 ± 186a	9.1	24220.5 ± 381a	6.5

3.3 Economic benefits of applying different forms nitrogen fertilizer As can be seen from Table 3, in terms of early bolting garlic, both the economic benefits of garlic stems and garlic bulbs, and the economic benefits per ha, are in the order of $T_3 > T_2 > T_1$; the economic benefits per ha under T_2 are 2628 yuan higher than under T_1, while the economic benefits per ha under T_3 are 6690 yuan higher than under T_1. Cangshan garlic shares the similar trend with early bolting garlic: $T_3 > T_2 > T_1$. The economic benefits per ha under T_2 are 3537 yuan higher than under T_1, while the economic benefits per ha under T_3 are 5490 yuan higher than under T_1.

Table 3 Economic benefits of different varieties of garlic under different treatments

Variety	Treatment	Economic benefits of garlic stems yuan/ha^{-1}	Economic benefits of garlic bulbs yuan/ha^{-1}	Economic benefits per ha yuan/ha^{-1}	Topdressing costs yuan/ha^{-1}	Income increase compared with T_1 // yuan/ha^{-1}
Early bolting garlic	T_1	61720.5	22596	84316.5	510	
	T_2	63901.5	23107.5	87009	574.5	2628
	T_3	68179.5	23580	91759.5	1263	6690
Cangshan garlic	T_1	25846.5	54568.5	80415	510	
	T_2	26341.5	57675	84016.5	574.5	3537
	T_3	28198.5	58129.5	86658	1263	5490

Note: For early bolting garlic, the price of garlic stems and garlic bulbs is 4.6 yuan/kg and 1.6 yuan/kg, respectively; for Cangshan garlic, the price of garlic stems and garlic bulbs is 3.4 yuan/kg and 2.4 yuan/kg, respectively; the price of urea, ammonium chloride and ammonium phosphor nitrate is 1700 yuan/t, 1000 yuan/t, and 2200 yuan/t, respectively.

4 Conclusions and discussions

With Cangshan garlic and early bolting garlic as experimental materials, this paper studies the effect of nitrogen topdressing on the garlic growth and yield of garlic stems and garlic bulbs. The results show that under the same amount of nitrogen, applying ammonium phosphor nitrate can better promote the growth of garlic than applying urea and ammonium chloride; both ammonium chloride and ammonium phosphor nitrate can effectively improve the yield of garlic stems and garlic bulbs, especially for ammonium phosphor nitrate; through economic benefit analysis, applying ammonium chloride and ammonium phosphor nitrate can produce greater economic benefits than applying urea, and especially ammonium phosphor nitrate increases the economic benefits of Cangshan garlic and early bolting garlic by 5490 yuan and 6690 yuan per ha, respectively. Thus, applying ammonium phosphor nitrate as topdressing for garlic can effectively increase yield and income. Different forms of nitrogen in the soil will be converted into each other, and then be absorbed by plants. Under suitable temperature, moisture and aeration conditions, due to the action of soil microbes and enzymes, urea is hydrolyzed into ammonium nitrogen, and ammonium nitrogen is oxidized into nitrate nitrogen. Nitrate and ammonium nitrogen can be directly absorbed by the plants, but plant absorption of nitrogen is mainly in the form of nitrate nitrogen, and excessive ammonium nitrogen may be toxic to plants. The fertilizers containing nitrate nitrogen can provide nitrogen for plants without conversion, while urea and ammonium nitrogen need to go through the conversion. And it is converted slowly in early spring and nitrogen supply is delayed, so ammonium phosphor nitrate has better effect than ammonium chloride and urea.

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