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Applied Research of Water and Fertilizer Integration Technology on Garlic

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Abstract: Garlic (*Allium Sativum* L.) is a favorite vegetable that is widely cultivated around the world. Traditional ditch irrigation and ground fertilization have many drawbacks, but the advantages of water and fertilizer integration are obvious. In order to study the effect of different irrigation and fertilizer treatments on the yield in a garlic field, the main garlic variety "er shui zao"in Dangyang city was used to be observed and compared the yield of garlic sprout and garlic bolt with different water and fertilizer integrated equipment and different fertilizer structures. Compared with the ditch irrigation treatment, irrigation water and fertilizer applications were reduced by 51.56% and 38.00% respectively both in the semi-fixed micro sprinkler irrigation treatment and mobile micro spray irrigation treatment throughout the growth cycle, but evident increase of the yields were found. The yields of garlic sprout and garlic bolt could reach 3845.56 kg/667m^2 and 1010.45 kg/667m^2 respectively in the treatment of semi-fixed micro-sprinkler irrigation combined with the leaf-specific water-soluble fertilizer. It could increase production and efficiency, and improve the water-fertilizer utilization ratio and mitigate the environmental contamination, achieving the production goal of saving costs and increasing profits.

Keywords: Water and Fertilizer Integration, Water Soluble Fertilization, Garlic

1. Introduction

Garlic (*Allium Sativum* L.) is popular for its unique nutrition and health care ingredients and medicinal value [1]. Its planting is a key project to promote agricultural supply-side structural reform in Dangyang City, Hubei Province which its annual planting area is 100,000 mu. With the increase in labor costs, simplify the cultivation technology is urgently needed to support the development of the garlic industry. Various environmental factors have a major impact on garlic growth and production, such as drought stress, fertilizers and pesticides, especially moisture. The humidity between garlic and garlic is difficult to be controlled because ditch irrigation is often used in the garlic cultivation, and the disease speeds up the flow through the water, resulting in a high incidence. Excessive amounts of fertilizers and irrigation water are used in agriculture, which not only wastes water resources, but also causes problems such as soil compaction and potential pollution of groundwater [2]. The water-fertilizer integration system is capable of monitoring a water content and a fertilizer utilization rate, saving water and fertilizer, increasing crop yields and alleviating environmental pollution, thus promoting sustainable development of agriculture[3]. Water and fertilizer integration cultivation techniques of garlic is the integration technique of irrigation and fertilization, micro-sprinkler irrigation is formed through pipes and nozzles, which could uniformly and quickly infiltrate the root of garlic. This ensures that the soil of garlic root system is always kept loose and suitable for water content[4, 5]. Also it can improve the resource utilization, increase the yields and reduce the pollution of the surrounding natural environment [6, 7].

However, it is difficult for farmers to grasp how to combine water-saving irrigation methods and different fertilizer structures to achieve the best effect on garlic cultivation. Therefore, the effects of the yield and water -fertilizer use

efficiency by different water and fertilizer coupling in garlic production were researched in this study, in order to guide farmers to strictly control the total amount of fertilization and the synchronization of water and fertilizer, and achieve high quality, high efficiency and ecological production of garlic. The results indicated that the semi-fixed micro-sprinkler irrigation used together with the leaf-specific water-soluble fertilizer was the best way to save fertilizer and water and increase yield of garlic.

2. Materials and Methods

2.1. Materials

The main garlic variety "er shui zao" in Dang yang city was used as material in this study. The experiment was carried out from September 2015 to April 2016 at the Light and Simplified Garlic Cultivation Demonstration Base in Lianghe Town, Dangyang City.

2.2. Experimental Design

2.2.1. Screening of Water and Fertilizer Integration Equipment

Three treatments were set up in this experiment, and three biological replicates were set for each treatment. The farmer's customary planting pattern was used as a control in CK1. The different treatments of water and fertilizer integration were used in treatment 1 and treatment 2. See Table 1 for details as follows. There were reservoirs in the fields of Treatment 1 and Treatment 2. The irrigation equipment consisted of pump, water meter, disc filter, venturi fertilization tank, 1.2-1.5 inch 5-hole spray belt, and so on. The power and pump of treatment 1 was fixed. Supply (distribution) water main pipes (sub pipe) were buried underground. The working branch pipe and the nozzle could be moved, water was supplied to the branch pipe by a water supply plug exposed to the ground and connected to main pipe (sub-pipe). The power, pumps, pipes and nozzles of treatment 2 were all mechanically moved and directly absorbed water from the reservoir. Spraying of special water-soluble fertilizer on leaf surface used in this study were all from Wuhan Ruilai Fertilizer Materials Co., Ltd. (Total nitrogen content: available phosphorus content: effective potassium content = 27:15:12).

Table 1. *Water and fertilizer integrated equipment screening test.*

Treatment	Irrigation method
CK1	Ditch irrigation
Treatment 1	Semi-fixed micro sprinkler irrigation
Treatment 2	Mobile micro spray irrigation

2.2.2. Fertilizer Screening Test

In this experiment, three treatments were set up, and three biological replicates were set for each treatment. Farmers' customary application of fertilizer was used as control in CK2 (water-soluble compound fertilizer N: P: K=15: 15: 15). Nutri green humic acid water soluble fertilizer was used in treatment 3, which was produced in Greentech (Suzhou) Humorganic Technology Ltd ((humic acid content ≥40g/L, $N+P_2O_5+K_2O$ content ≥200g/L, organic matter content ≥20%). Spraying of special water-soluble fertilizer on leaf surface was used in treatment 4, which was from Wuhan Ruilai Fertilizer Materials Co., Ltd (Total nitrogen content: available phosphorus content: effective potassium content = 27:15:12). Semi-fixed micro-sprinkler system was used in CK2, treatment 3 and treatment 4.

2.2.3. Test Implementation

The experiment plot was 36 m^2 with 6 m lengths and 6 m widths. Three biological replicates were set, and a total of 18 plots were used in this study. Each plot contained 600 lines. One micro-nozzle was laid every 300 lines. Garlic planting space was 6cm×10cm. There are protection lines around. The sowing date of garlic is August 10th. The method of measuring production was as follows: Firstly, the yields of garlic sprout and garlic bolt were measured in each plot. Secondly, the yields per hectare were calculated based on the planting density. Field management was carried out by farmers in accordance with local routine operations.

3. Results and Analysis

3.1. Comparison of the Effects of Water and Fertilizer Saving Under Different Irrigation Treatments

Treatment 1 and Treatment 2 were treated with the same water and fertilizer irrigation, irrigated for 12 times and each time about 1 hour that depended on the soil water content before irrigation in the whole growth stage, and finally the total irrigation amount was counted. As shown in Table 2, compared with the traditional ditch irrigation, the irrigation water-saving amount and the water-saving rate both in treatment 1 and treatment 2 using water and fertilizer integration irrigation were 165 $m^3/667m^2$ and 51.56%, respectively. Five times of fertigation were used in the whole garlic growth stage, the fertilizer-saving amount of them was 11.40 $kg/667m^2$ which reduced fertilizer use by 38.00%, achieving to reduce cost and increase benefit. Effects of water-saving and fertilizer-saving in Semi-fixed micro sprinkler irrigation and Mobile micro spray irrigation were the same, which were better than in Ditch irrigation.

Table 2. *Water-saving and fertilizer-saving effects of different treatments.*

Treatments	Irrigation amount(m3/667m^2)	Water-saving amount compared with CK	Water-saving rate (%)	Fertilizer content (kg/667m^2)	Fertilizer-saving (kg/667m^2)	Fertilizer-saving rate (%)
CK	320.00	/		30.00	/	
1	155.00	165.00	51.56	18.60	11.40	38.00
2	155.00	165.00	51.56	18.60	11.40	38.00

3.2. Effects of Different Irrigation Treatments on Yield

The results of Table 3 showed that the yields of garlic sprout and garlic bolt were significantly affected by different irrigation treatments. The yield of treatment 1 was the highest, and the yields of garlic sprout and garlic bolt were 50.13% and 34.65% higher than that of CK1, respectively, which showed extremely significant differences. The yield of treatment 2 was the second highest. Compared with the yield of CK1, the yields of garlic sprout and garlic bolt increased by 43.50% and 31.42%, respectively, which showed extremely significant differences. Yet, there was no significant yield difference between treatment 1 and treatment 2.

Table 3. *Yield-increasing effects of different irrigation treatments.*

Treatments	The yield of garlic sprout ($kg/667m^2$)	Increasing yield compared with CK1 (%)	The yield of garlic bolt($kg/667m^2$)	Increasing yield compared with CK1 (%)
CK1	2567.54bB	/	750.43 bB	/
1	3854.56aA	50.13	1010.45 aA	34.65
2	3684.32 aA	43.50	986.22 aA	31.42

Note: Different lowercase letters in the same column data indicate significant difference ($p<0.05$), and different uppercase letters indicate significant difference ($p<0.01$).

3.3. Effects of Different Fertilization Treatments on Yield

The results of Table 4 indicated that the yields of garlic sprout and garlic bolt were also affected used the semi-fixed micro-sprinkler system by different fertilizer treatments. The yield of treatment 4 was the highest, and the yield of garlic sprout and garlic bolt were 8.42% and 24.00% higher than that of CK2, respectively, exhibiting extremely significant differences. Yet, the yield of treatment 3 was not significantly different from that of CK2. Thus the semi-fixed micro-sprinkler irrigation used together with the leaf-specific water-soluble fertilizer was the best way of water and fertilizer integration to increase yield of garlic the case of water-saving and fertilizer-saving in this study.

Table 4. *Effect of different fertilization treatments on yield increase.*

Treatments	The yield of garlic sprout ($kg/667m^2$)	Increasing yield compared with CK2 (%)	The yield of garlic bolt($kg/667m^2$)	Increasing yield compared with CK2 (%)
CK2	3555.21bB	/	814.87bB	/
3	3614.56 bB	1.67	843.12 bB	3.47
4	3854.56aA	8.42	1010.45 aA	24.00

Note: Different lowercase letters in the same column data indicate significant difference ($p<0.05$), and different uppercase letters indicate significant difference ($p<0.01$).

4. Discussion

Many factors constrain agricultural production, especially water and fertilizer. The water and fertilizer integration technology are becoming more and more popular because of their numerous advantages over traditional methods of irrigation and fertilizer application, such as water-saving, fertilizer-saving, high quality and high yield[8].

Meantime, the comprehensive cultivation technology of water and fertilizer integration can be highly mechanized, greatly improve production efficiency and significantly reduce labor cost [9-12]. The sprinkler irrigation system eliminated the water ditches in the field, eliminating the need to renovate the ditches and remove weeds, reducing the occurrence of diseases such as rotten roots of garlic, and avoiding the phenomenon that some garlic seeds were not germinated due to uneven irrigation or water shortage caused by conventional irrigation. Under the same conditions, the labor required for sprinkler irrigation systems is only one-fifth of which for surface irrigation[13-15]. Furthermore, sprinkler irrigation with pipeline did not require excessive irrigation ditches and ridges, which can increase the area of garlic cultivation by 7% to 10%, thus increasing the yield of garlic. These advantages bring greater economic benefits to farmers while protecting the surrounding natural environment.

5. Conclusion

Main purpose of Dangyang garlic cultivation was to harvest garlic sprout and garlic bolt. Our research showed that Effects of water-saving and fertilizer-saving in Semi-fixed micro sprinkler irrigation and Mobile micro spray irrigation were the same, which were better than in Ditch irrigation.

Water and fertilizer integration increased the yield of garlic sprout by 46.82% and garlic bolt by 33.04% compared with conventional irrigation and fertigation treatment, achieving the production goal of saving costs and increasing profits.

The semi-fixed micro-sprinkler irrigation used together with the leaf-specific water-soluble fertilizer was the best way of water and fertilizer integration to increase yield of garlic the case of water-saving and fertilizer-saving.

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