

Impact of Water-Nitrogen Coupling on the Growth Characteristics of Ornamental Sunflowers

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Abstract. As an important resource regulation method in agricultural production, water-nitrogen coupling has a significant synergistic effect on crop growth. This paper takes ornamental sunflower (*Helianthus annuus* L.) as the research object. By integrating the topdressing of compound fertilizer and the ratio of base fertilizer, it explores the effects of different water-nitrogen coupling modes on its growth, physiological characteristics, and ornamental quality. The results show that appropriate irrigation combined with nitrogen fertilizer application can significantly increase plant height, flower disc diameter, and flowering uniformity. Appropriate coupling of water and nitrogen significantly increases plant height, capitulum diameter and cut - flower yield. Among them, the W3N3 treatment shows the best comprehensive performance.

Keywords: Ornamental Sunflowers; Water-Nitrogen Coupling; flower diameter.

1. Introduction

Ornamental sunflowers are widely used in landscape architecture and the cut flower market due to their bright colors and upright plant shapes[1]. However, their high sensitivity to water and nitrogen during the growth process makes their yield and quality vulnerable to improper resource management. Recent studies have shown that water-nitrogen coupling can significantly affect crop growth by regulating physiological processes such as root absorption, photosynthesis, and nutrient allocation[2].

However, most of the existing research focuses on food crops, and there is a lack of systematic exploration of the water-nitrogen synergy mechanism in ornamental plants[3]. Based on the experiments of topdressing compound fertilizer and the ratio of base fertilizer, combined with the theory of water-nitrogen interaction, this study aims to clarify the optimal water-nitrogen management mode for ornamental sunflowers and provide technical reference for landscape horticultural production[4].

2. Materials and Methods

2.1 Overview of Test Sites

To explore the effects of different water-nitrogen combinations on the growth characteristics, nitrogen absorption, and ornamental quality of ornamental sunflower (*Helianthus annuus*), a split-plot field experiment was carried out at the Yimin Irrigation Experiment Station in Minle County, Zhangye City, Gansu Province from May to August 2024. Three water gradients were set in the main plot: low water W1 (soil water content accounted for 55% - 65% of field capacity FC, moderate water deficit), medium water W2 (soil water content accounted for 65% - 75% of field capacity FC, mild water deficit), and high water W3 (soil water content accounted for 75% - 85% of field capacity FC, full irrigation). The results showed that appropriate water-nitrogen coupling

significantly increased plant height, flower disc diameter, and cut flower yield. The W2N2 treatment had the best overall performance.

2.2 Experimental design

A split-plot design was adopted, with the main plot being the drip irrigation amount (W1 - W3) and the sub-plot being the nitrogen application rate (N1 - N3), with 3 replications, a total of 27 plots. The tested variety was the ornamental sunflower "Liri", sown on May 4th, with a row spacing of 60 cm and a plant spacing of 40 cm. Nitrogen fertilizer was applied in batches by drip irrigation as base fertilizer (40%), at the budding stage (30%), and at the flowering stage (30%). The base fertilizers used were ternary compound fertilizer (Ndayudengyu15%, $P_2O_5 \geq 15\%$, $K_2O \geq 15\%$), superphosphate ($P_2O_5 \geq 12\%$), potassium sulfate ($K_2O \geq 51\%$), and granular organic fertilizer (organic matter content $\geq 45\%$); the topdressing was urea ($N \geq 46\%$). At the full-bloom stage, 5 plants were randomly selected from each treatment to measure the flower disc diameter, fresh weight, and dry weight of the flower disc.

2.3 Measurement Indicators and Methods

Plant height: Measure the height from the base of the plant to the growing point with a steel tape measure (accuracy: 1 mm).

Use a ruler or other measuring tools to directly measure the diameter of the sunflower head. During the measurement process, factors such as the height of the sunflower plant and the excessive weight of the sunflower head during the mature period causing the upper stem to bend may affect the accuracy of the measurement.

Data analysis was carried out using SPSS software. One-way analysis of variance (ANOVA) was used to test the significance of the effects of water, nitrogen, and their interactions on each index.

3. Results

3.1 Plant height

As shown in Figure 1, The treatments at the W3 level under the N2 and N3 levels generally performed well and obtained the highest plant height data. This indicates that under higher irrigation conditions, an appropriate increase in nitrogen application may help increase plant height. However, from the overall trend, the treatments at the W2 and W3 levels under the N2 and N3 levels generally performed well, especially the N3W3 and N2W2 treatments, which both obtained the highest plant height data. This indicates that under higher irrigation and nitrogen application conditions, it may help increase plant height, especially at the N3 level.

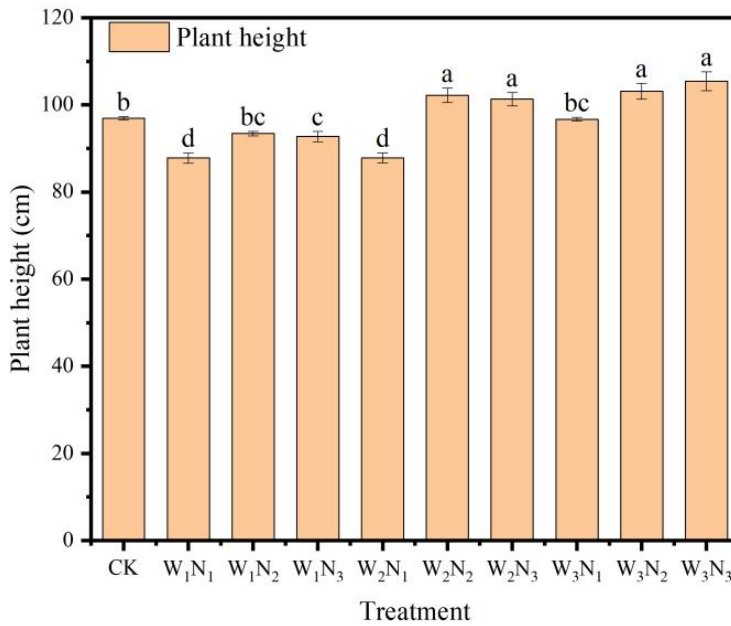


Figure 1 Effects of different water-nitrogen treatments on plant height of ornamental sunflower during the flowering period

3.2 Flower diameter

As shown in Figure 2, Among all the treatments, the diameter of the capitulum is between 20 cm and 28 cm. Among them, the flower diameter of the W₃N₃ treatment is the largest, reaching 28 centimeters. This indicates that under a relatively high nitrogen level, appropriate irrigation can significantly increase the flower diameter. Under a fixed nitrogen application level, the capitulum diameter increases with the increase of the irrigation level. The flower diameter of the treatment at the fixed nitrogen application level of N₁ is relatively small, indicating that the growth of flowers may be restricted to a certain extent under the N₁ level.

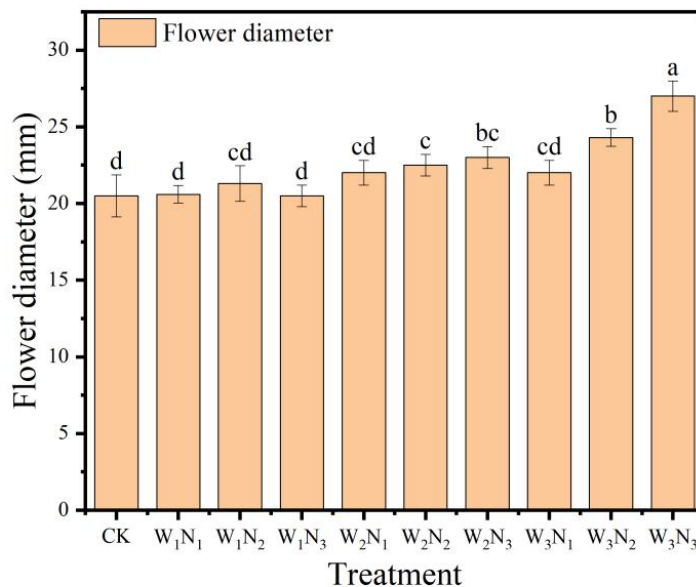


Figure 2 Effects of different water-nitrogen treatments on flower diameter of ornamental sunflower during the flowering period

3.3 Flowering period

As shown in Figure 3, The processing of flowering days ranges from 13 d to 21 d, among which the ornamental period days of W2N2 and W2N3 treatments are the longest, being 20.3 d and 19.67 d respectively, which significantly ($P < 0.05$) increased by 32.67% and 28.36% compared to the control CK. At a fixed nitrogen level, the ornamental period days of the N1 level treatment are relatively short, indicating that the ornamental period of plants may be somewhat limited at the N1 level. At the N2 level, the W2 level treatment (W2N2) has the longest ornamental period days, being 20.3 d, significantly ($P < 0.05$) higher than other treatments at the same nitrogen level. At the N3 level, the W2 level treatment (W2N3) also has a longer ornamental period days, being 19.67 d, significantly ($P < 0.05$) higher than the W1N3 treatment, and also shows a longer ornamental period compared to the W3N3 treatment. This indicates that at higher nitrogen levels, appropriate watering can significantly prolong the ornamental period.

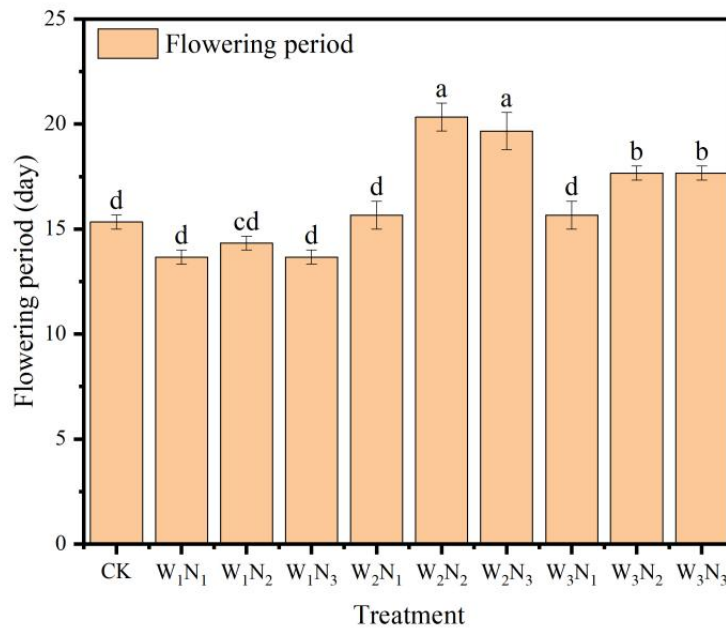


Figure 3 Effects of different water-nitrogen treatments on flowering period of ornamental sunflower during the flowering period

4. Discussion

Zou et al. [5] It was concluded that Appropriate water-nitrogen management is crucial for promoting the increase in the flower diameter of ornamental sunflowers. In particular, medium-level nitrogen fertilizer combined with appropriate water supply can significantly increase the flower diameter. As the irrigation amount increases, the flower disc diameter gradually increases; the flower disc diameter with nitrogen application is significantly higher than that without nitrogen application, and there is no significant difference between optimized nitrogen application and excessive nitrogen application[6]. Under the same nitrogen application conditions, as the irrigation amount increased, the total nitrogen uptake showed an upward trend.

Emina et al.[7]It was concluded that Water and fertilizer management are key factors affecting the growth and development of ornamental sunflowers. Among them, water and nitrogen are two of the most important nutrients for plant growth, and their interaction has an important impact on plant growth and development. Zhao et al.[8]discovered that The water-nitrogen coupling effect has been widely studied in crop production, but relatively little research has been done on ornamental plants, especially ornamental sunflowers. Therefore, in depth study of the impact of water-nitrogen coupling on the flower disc of ornamental sunflowers is of great significance for optimizing cultivation management and improving ornamental quality[9].

5. Conclusions

This study systematically explored the effects of water-nitrogen coupling on the growth and development of the flower disc of ornamental sunflowers, and the following main conclusions were drawn:

Water and nitrogen coupling has a significant impact on the growth and development of ornamental sunflower capitulum, with an obvious interaction between water and nitrogen. The coupling treatment of high water (75%-85% of field water holding capacity) and high nitrogen (180 kg/hm²) is most conducive to the growth and development of ornamental sunflower capitulum, which is manifested in the largest capitulum diameter, heaviest weight, most seeds, and best quality. Coupling treatment of medium water (65%-75% of field water holding capacity) with medium or high nitrogen is most beneficial for increasing the number of days for ornamental sunflower viewing. This study provides a theoretical basis and practical guidance for the scientific cultivation of ornamental sunflowers and is of great significance for improving the ornamental value and economic benefits of ornamental sunflowers. Future research can further explore the impact of water and nitrogen coupling on other ornamental traits of ornamental sunflowers, as well as adaptability under different environmental conditions, providing a more comprehensive scientific basis for the precise cultivation of ornamental sunflowers.

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