

Effect of water-nitrogen coupling on growth and yield of edible sunflower

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Abstract. In order to reveal the effect of water and nitrogen coupling on the growth and yield of edible sunflower in Hexi area, based on the field experiment, using edible sunflower “JK601” as the test material, the split-area experimental design was adopted, and a two-factor two-factor fully-treated plot experiment of water and nitrogen was carried out under drip irrigation conditions. The results showed that water-nitrogen coupling had a significant effect on plant height of edible sunflower. the highest plant height was obtained in T2 and T7 treatments (249.87 cm and 249.03 cm), and the highest yield was obtained in T7 treatment (5304.33 kg/m²), which was significantly higher than that of T17 treatment (18.91%). The yields of moderate irrigation and fertilization (W1 and N1) were better than those of high water and high N treatments, indicating that moderate fertilization can significantly increase yields under moderate irrigation conditions in Hexi region.

Keywords: Water-nitrogen coupling, edible sunflower, plant height, yield.

1. Introduction

Edible sunflower is one of the important cash crops [1]. Edible sunflower plants are tall and robust, with strong drought resistance, salinity tolerance and tolerance of poor soil conditions [2-4]. In this paper, the water-fertilizer coupling method of “transporting water with water and regulating water with fertilizer” was adopted to plant edible sunflower in the cold and arid region of Hexi to achieve the coordination of irrigation, water replenishment, and fertilizer application with the crop's water and fertilizer needs, which can effectively alleviate the problem of low utilization of soil and water resources in the Hexi region. It is of great significance to the scientific use of water and fertilizer resources, to improve the yield and quality of edible sunflower, to raise the income level of local farmers, to improve the ecological environment and to guarantee the sustainable development of agricultural resources.

2. Materials and Methods

2.1 Overview of the Experimental Site

This experiment was conducted from May to September 2024 at the Yimin Irrigation Experiment Station in Minle County, Zhangye City, Gansu Province (38° 39' N, 100° 43' E, with an average altitude of 1970 m). This area is located in the northern foot of the Qilian Mountains in the middle section of the Hexi Corridor, featuring a semi-arid climate and a continental desert steppe climate. The annual maximum temperature in this region is 37.1 °C, with an average annual temperature of approximately 7.6 °C. The average annual sunshine duration is around 3000 hours, and the average frost-free period is 109 to 174 days, indicating abundant light and heat resources. The average annual precipitation is 183 to 285 mm, with little and concentrated rainfall, and the annual evaporation exceeds 2000 mm, making the climate dry. The main source of irrigation water is the meltwater from the Qilian Mountains, highlighting a significant contradiction between water supply

and demand. The soil type in the experimental field is light soil, with a field capacity of 24% in the 0-60 cm soil layer, a soil bulk density of about 1.4 g/cm^3 , a groundwater depth of more than 20 m, medium fertility, and no salinization.

2.2 Experimental design

Edible sunflower variety “JK601” was selected for this experiment with a growing period of about 140 days. The planting method proposed in this study was flat mulching planting with two rows per film. The width of the film was 100 cm and the thickness was 0.01 mm. Wide and narrow rows were planted, with narrow rows spaced 50 cm apart and wide rows spaced 80 cm apart.

This experiment was designed in a split-plot design. It included three irrigation levels and four nitrogen application levels. The experiment was fully combined with 16 treatments and one control (CK). Each treatment and control was replicated three times with a total of 51 plots. Fully irrigated W0 (75%-85% FC), mildly water deficient W1 (65%-75% FC) and moderately water deficient W2 (55%-65% FC). The four nitrogen application levels were N0 (240 kg/hm² of nitrogen), N1 (180 kg/hm² of nitrogen), N2 (120 kg/hm² of nitrogen) and N3 (no nitrogen fertilizer). Before sowing, all the phosphorus fertilizer (calcium superphosphate) (300 kg/hm²), potash fertilizer (potassium sulphate) (300 kg/hm²), and 40% of nitrogen fertilizer (diammonium phosphate) were spread as basal fertilizer. The remaining 60% of nitrogen fertilizer was spread as basal fertilizer.

Table 1 Design of Water and Nitrogen Regulation Experiment for Edible Sunflower

Treatments		Lower limit of irrigation ~ upper limit of irrigation (Soil water content as % of field water holding capacity)				Nitrogen application (kg/hm ²)
		Seedling stage	Budding stage	Flowering stage	Maturing stage	
T1	CK	75~85	75~85	75~85	75~85	240
T2	W1W1W0N0	65~75	65~75	75~85	75~85	240
T3	W1W1W0N1	65~75	65~75	75~85	75~85	180
T4	W1W1W0N2	65~75	65~75	75~85	75~85	120
T5	W1W1W0N3	65~75	65~75	75~85	75~85	0
T6	W1W1W0N0	65~75	65~75	75~85	65~75	240
T7	W1W1W0N1	65~75	65~75	75~85	65~75	180
T8	W1W1W0N2	65~75	65~75	75~85	65~75	120
T9	W1W1W0N3	65~75	65~75	75~85	65~75	0
T10	W1W0W2N0	65~75	75~85	75~85	55~65	240
T11	W1W0W2N1	65~75	75~85	75~85	55~65	180
T12	W1W0W2N2	65~75	75~85	75~85	55~65	120
T13	W1W0W2N3	65~75	75~85	75~85	55~65	0
T14	W2W0W1N0	55~65	75~85	75~85	65~75	240
T15	W2W0W1N1	55~65	75~85	75~85	65~75	180
T16	W2W0W1N2	55~65	75~85	75~85	65~75	120
T17	W2W0W1N3	55~65	75~85	75~85	65~75	0

2.3 Measurement items and methods

2.3.1 Growth indicators

When sunflower entered the seedling stage, three sunflower plants with consistent growth were selected from each plot and measured every 10 days. Plant height: a steel tape measure with an

accuracy of 1 mm was used to determine the distance from the base of the sunflower to the highest growth point.

2.3.2 Yield

Total yield: At the end of the ripening period, the whole area was harvested for each treatment and the total mass was weighed for final calculation of hectare yield.

3. Results

3.1 Effect of water-nitrogen coupling on the height of edible sunflower plants

The superiority of edible sunflower growth directly reflects the water and nitrogen uptake and utilization of edible sunflower plants under different water and nitrogen combinations, which indirectly affects the yield of edible sunflower[5]. Yavuz Delen[6] et al. analyzed morphological traits in sunflower through a genome-wide association study and showed that plant height and stem thickness were important traits affecting sunflower yield and were positively correlated with seed yield. Milan[7] et al. studied the heritability of plant height and head diameter in sunflower and found that plant height is one of the important traits affecting yield and has high heritability, which suggests that plant height can be optimized by selection to improve yield.

Plant height is an important index describing the growth and development of sunflower, and its size is affected by the technical management level of its own genetic characteristics. As can be seen from Table 2, different water nitrogen treatments of edible sunflower plant height changes in the whole reproductive period is basically the same trend, the seedling plant is small, slow growth, the fastest growth in the bud stage, the growth rate of the flowering stage is gradually slowing down, assimilates to the development of the disk, the maturity of the sunflower plant height growth is basically stable, at this time, the T2 and T7 treatments showed the optimal value of the whole reproductive period of the plant height, respectively, for the 249.87cm and 249.03cm. The effects of different water and nitrogen regulation on plant height of edible sunflower at all reproductive stages reached highly significant levels ($P < 0.01$). At the same level of nitrogen application, the more water irrigation, the greater the trend of sunflower plant height growth, in which the difference between W0 and W1 was not obvious, but basically higher than W2. The differences in the effect of nitrogen application levels on plant height were not significant. Under the conditions of W0 and W1, the plant height increased with the increase of nitrogen application, both of which showed $N0 > N1 > N2 > N3$, and the difference of plant height under the conditions of N0 and N1 was very small and basically remained at the same height.

Table 2 Effect of water and nitrogen regulation on plant height(cm) of edible sunflower plants

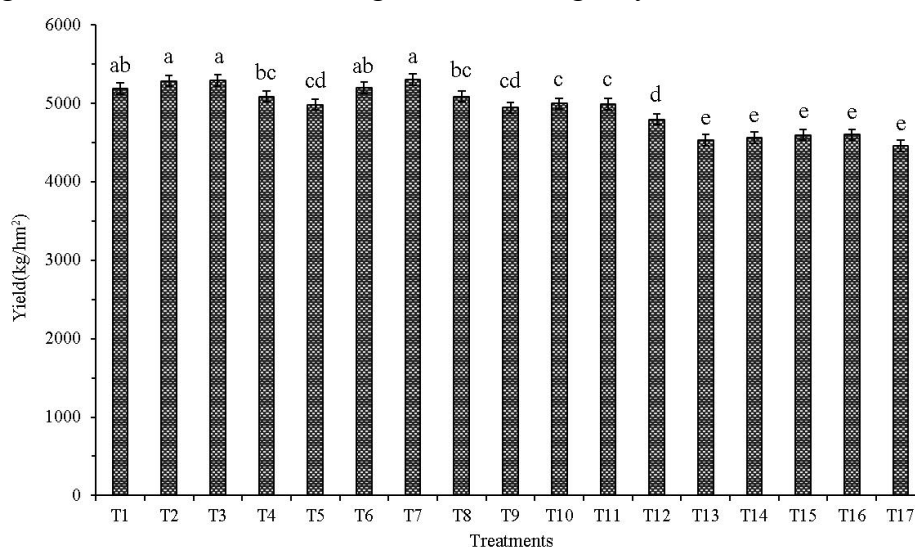
Treatments	Seedling stage	Budding stage	Flowering stage	Maturing stage
T1	40.27±1.45ab	175.67±6.66abc	234.70±5.03bc	237.87±2.22bc
T2	41.50±0.80a	182.33±6.51a	245.67±5.77a	249.87±2.61a
T3	41.97±2.08a	176.00±3.61ab	234.33±4.73bc	239.00±3.61bc
T4	35.87±0.25bcd	174.67±4.51abc	233.67±3.51bc	237.33±4.73bc
T5	33.27±4.96defg	165.67±2.52def	224.40±5.50cde	228.97±3.62cd
T6	38.37±0.49abc	168.00±2.65cde	236.87±2.80ab	241.00±7.24ab
T7	40.60±1.15ab	182.07±2.90a	245.73±6.02a	249.03±9.00a
T8	36.30±1.47bcd	176.67±7.02ab	232.00±2.00bc	236.73±5.51bc
T9	33.80±1.13cdef	172.67±3.06bcd	226.33±4.73bcd	229.27±2.05cd
T10	38.03±0.15abc	168.00±2.00cde	219.33±9.02de	223.33±4.16d

T11	38.43±0.45abc	164.63±3.46ef	214.67±5.03ef	220.33±3.51de
T12	35.30±0.46cdef	161.33±2.89ef	208.33±6.51fg	213.33 ±5.86ef
T13	30.83±4.01efg	158.33±2.52f	199.33±10.69g	205.00±5.00f
T14	28.80±4.51g	159.93±4.50f	200.67±3.06g	207.67±7.51f
T15	29.43±4.01fg	159.33 ±3.79f	188.00±9.17h	194.00±6.56g
T16	30.43±3.64fg	162.67±0.58ef	205.00±7.81fg	213.00±6.00ef
T17	24.60±2.11h	138.27±5.75g	163.67±4.50i	168.00±9.54h
W	**	**	**	**
N	**	**	**	**
W×N	ns	**	**	**

3.2 Effect of water-nitrogen coupling on yield of edible sunflower

Water-nitrogen interaction favors crop growth and development and promotes yield, quality and water-nitrogen use efficiency[8]. The yield of edible sunflower under different water and nitrogen regulation is shown in Fig. 1.As can be seen from Fig. 1, the highest and lowest yields were obtained from T7 and T17 treatments, which were 5304.33 kg/hm² and 4460.75 kg/hm², respectively, with a significant increase in yield of 18.91% in T7 treatment compared with that of T17 treatment, and the difference was not significant when compared with that of CK. Under the same level of nitrogen application, with the increase of irrigation water, the yield showed the trend of increasing and then decreasing, and the change of yield with irrigation water showed W1 > W0 > W2. Under the same level of irrigation water, the yield of nitrogen application treatment had a significant increase compared with that of non-nitrogen application treatment, which was shown as N1 > NO > N2 > N3. The above results showed that the yield of edible sunflower under the high water and high nitrogen treatments was not the highest, which indicated that under the premise of moderate irrigation water The above results showed that the yield of edible sunflower was not the highest under the high water and high nitrogen treatment, indicating that moderate fertilization under moderate irrigation can promote the increase of edible sunflower yield.

Fig. 1 Effect of water and nitrogen conditioning on yield of edible



sunflower

4. Discussions

The effect of water-nitrogen coupling on the growth and development of edible sunflower is mainly reflected in the differences in plant height exhibited by different water-nitrogen combinations. The stalks of edible sunflower, as a nutrient transporting mechanism, are crucial for plant growth and disk development. The stalks are not only responsible for transporting nutrients from the root system to the disk but also provide support to the plant[9]. Adequate water and nitrogen supply can promote rapid plant growth, as evidenced by increased plant height and enhanced stem thickness. Insufficient water or nitrogen deficiency can lead to plant growth limitation and significant reduction in plant height and stem thickness. Wang Xingzhen et al. [10]found through principal component analysis that plants with higher plant height usually have stronger photosynthetic capacity and nutrient transport capacity, which can provide more material basis for the development of flower discs and seeds, while stem thickness directly affects the plant's ability to support and resistance to collapse, and thicker stalks can better support flower discs and reduce yield loss caused by collapse. Appropriate irrigation and nitrogen fertilizer supply can significantly increase plant height and stem thickness, thus increasing yield. However, high levels of irrigation and fertilization do not give optimal yield benefits and may lead to resource wastage and environmental problems, so scientifically sound water and nitrogen management is needed.。

5. Conclusion

The effect of water-nitrogen coupling on the growth and development of edible sunflower was mainly manifested in plant height, which was an important indicator of sunflower growth, reaching the fastest growth rate at the bud stage and stabilizing at the maturity stage. The results showed that T2 and T7 treatments had the highest plant height (249.87 cm and 249.03 cm, respectively). The effect of N application level on plant height and stem thickness was not significant, but all N applied treatments were superior to the unapplied treatments. In terms of yield, T7 treatment gave the highest yield (5304.33 kg/hm²), which was significantly higher by 18.91% compared to T17 treatment. The yield performance of moderate irrigation and fertilization (W1 and N1) was better than that of high water and high nitrogen treatments, indicating that rational fertilization can significantly increase sunflower yield under moderate irrigation conditions. The results indicated that water-nitrogen interactions have significant effects on sunflower growth and yield, and moderate water and nitrogen management is the key to achieve high yield.

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