RESEARCH ARTICLE

Effects of different irrigation amounts considering transpiration on greenhouse cherry yield and quality

Zhe An[1, *], Chunhang Wang[2]

[1]Department of Agriculture, [2]Quality Supervision Office, Tangshan Vocational and Technical College, Tangshan, Hebei, China

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Cherries are rich in nutrients and have high economic benefits from their wide range of applications in the food industry and drug development. To save the use of water resources and, at the same time, to get the optimal crop economic efficiency, the study was conducted on the greenhouse cultivation of cherries, taking into account transpiration, to calculate the amount of irrigation in order to get the best yield and quality of cherries and at the same time to consume the least amount of water resources. Firstly, greenhouse transpiration and the factors affecting it were tested. The results showed that cherry transpiration varied rapidly at higher ambient humidity in the room with daily transpiration variations kept within 150 g. The cherries were able to maintain a low level of transpiration when the average daily relative air humidity was greater than 80%. The irrigation amount was then calculated according to the daily transpiration of cherries. The results showed that the yield was 2.83 kg/plant in 120% daily transpiration treatment, which was 23.9%, 11.1%, and 3.2% higher than that in 80%, 100%, and 140% treatments, respectively. 80% transpiration treatment had the highest water utilization efficiency of 39.6 kg/m^3, while the lowest irrigation water utilization efficiency was 26.9 kg/m^3 in 140% transpiration treatment. The study demonstrated that irrigation at 120% evapotranspiration resulted in the best fruit quality, while 140% evapotranspiration treatment resulted in the lowest total fruit quantity and quality. The findings not only provided a scientific basis for irrigation management of cherry, but also might provide a valuable reference for irrigation research of other crops.

Keywords: transpiration; greenhouse cultivation; cherry; irrigation; agriculture.

[*]**Corresponding author:** Zhe An, Department of Agriculture, Tangshan Vocational and Technical College, Tangshan 063000, Hebei, China. Email: anzhe445566@126.com.

Introduction

China is a major agricultural country with significant different and ever-changing terrain, landforms, and climate environments. According to different soils, landforms, seasons, and crops, different management methods have been adopted, creating diverse agricultural production models [1]. From tropical agriculture in the south to cold agriculture in the north, from coastal plains in the east to mountainous plateaus in the west, the regional types of agriculture in China are very diverse. However, the water resources situation in China is not optimistic with problems such as uneven distribution of water resources, poor utilization rate, and low per capita occupancy. With the advancement of industrialization, water pollution has been increasing rapidly, especially in lakes and river environments, which have had a significant impact on residents' drinking water and agricultural irrigation water. Meanwhile, due to population growth and industrial development, China's water consumption is increasing in various aspects, and the deteriorating ecological environment also requires more water resources for restoration, which further exacerbates the scarcity of water resources [2]. To save water, the traditional flood irrigation is converted into scientific controlled water-saving drip irrigation and infiltration irrigation and combined with the characteristics of crop transpiration and water demand for farm water to improve the effective utilization rate of agricultural irrigation. A reasonable irrigation system is the key to ensuring crop yield and quality. Water supply affects crop growth and the accumulation of quality and flavor. Excessive irrigation can lead to the breeding of diseases and pests.

Chinese cherry is one of the main cultivated varieties of cherry, widely distributed in China, and an important cash crop. It is often cultivated in greenhouses and mainly relies on manual allocation for irrigation, which is greatly affected by irrigation methods [3]. To increase the economic value of cherries and improve the utilization rate of agricultural water resources, transpiration is considered for irrigation allocation. Transpiration is an important way of exchanging resources with the outside world in plant growth and breeding. Reasonable irrigation based on transpiration can reduce water consumption and facilitate plant growth. Many studies have been done in transpiration, irrigation methods, and their interactions. Brum *et al*. studied the importance of replacing rainwater irrigation with artificial irrigation to address drought issues to alleviate the pressure of oil palm plantations facing drought and water scarcity conditions in the eastern Amazon region of Brazil. They observed the transpiration of the plantation during the extremely dry season, the impact of reduced precipitation and water supply differences on oil palm, and the plant characteristics under different irrigation treatments, and found that, in sprinkler and drip irrigation systems, irrigation increased fruit yield by 35% and 26%, respectively [4]. *Speckman* et al. applied AquaFlux software to process and analyze heat dissipation probe (TDP) data to quantify transpiration at the plant level, which could continuously import raw TDP values, analyze data in real-time, and make predictions based on the data, effectively promoting the understanding of plant transpiration prediction [5]. Further, *Yudina* et al. investigated the effects of Variation Potential (VP) generated by local burns of peas under different air humidity conditions on transpiration and carbon dioxide assimilation. The results showed that VP induced multi-stage changes in intact pea leaves. Under high humidity conditions, rapid and prolonged decreases in transpiration were significantly inhibited, while slow increases in transpiration were almost independent of air humidity. The dependence of VP induced CO_2 assimilation reaction on air humidity exhibited semblable characteristics [6]. *Song* et al. assessed various irrigation scheduling methods in water quality protection, water-saving, and greenhouse-gas emissions to improve the sustainability of irrigation. An information driven irrigation scheduling method built on soil water sensing and modeling was implemented on beans and turf. The results showed that this method could raise the sustainability of irrigation by deducting water consumption and nutrient loss to aquifers while keeping agricultural productivity [7]. In addition, Gao et al. investigated the characteristics of salt washing in *Juglans regia* irrigation areas and proposed an empirical framework for maintaining soil quality in *Juglans regia* irrigation areas through irrigation and salt washing [8]. Du *et al*. verified the spectral response mechanism to soil moisture and salinity through statistical tests and established a moisture and salinity spectroscopy (MSS) model. The results showed that, during the irrigation stage, the effects of water and salinity (W&S) underwent constant promoting changes and changes from inhibition to promotion over time, respectively. The MSS had achieved reliable accuracy in estimating W&S [9]. Bond *et al*. identified the key hormone regulators for flower bud rupture in sweet cherries by applying two chemical dormancy disruptors and confirmed that dormancy disruptors had no adverse effects on fruit quality during harvest or storage [10]. Current research mainly focuses on the analysis of the nutritional composition of cherries and the application of gene editing technology. There is a relative lack of research on the growth status of cherries under specific environmental conditions, especially under greenhouse conditions, and the relationship between yield and quality. This research gap not only limits the sustainable development of the cherry industry, but also affects the overall utilization of cherry as a cash crop. This study investigated the effects and impact of different irrigation amounts designed based on transpiration effect on the yield and quality of greenhouse cherries in order to fill this research gap and to provide a scientific basis for the efficient and sustainable production of cherries.

Materials and Methods

Plant resource and cultivate conditions

A total of 100, three-year old, red light cherry (*Prunus avium*) trees from Tai'an Longshuo Seedling Co. Ltd (Tai'an, Shandong, China) were included in this study. All the plants were cultivated in the greenhouse with 20-25°C temperature, 60-70% humidity, 0.5 m/s air flow rate, and 200 $\mu mol/m^2/s$ light intensity in Irrigation Experimentation Centre Station (Beijing, China). The HortiMax environmental recorder (HortiMaX, Maasdijk, Netherlands) was used to monitor and record the air temperature, air relative humidity, and solar radiant intensity in the greenhouse. The drip irrigation method was adopted with the drip irrigation pipes arranged in two rows and applied every morning. Cherry branches were divided into developmental branches and fruiting branches based on the appearance of flower buds. The fruiting branches were further divided into short, medium, long, mixed, and bouquet shaped fruiting branches. The proportion of different types of fruiting branches was related to variety, tree age, and management methods. Cherry short fruit branches and flower cluster like short fruit branches were more commonly cultivated in dwarf dense planting.

Sampling and data collection

Samples and data were collected monthly by random sampling method. The measurement of photosynthetic characteristics of cherry trees was conducted from 9:00 a.m. to 11:30 a.m. on a sunny day. After the cherry trees entered the harvesting period, they were harvested twice in the early and late stages. The qualities of harvested fruits were then determined by measuring the fruit quality parameters including hardness measured by using FHR-5 Hardness Tester (Takemura, Tokyo, Japan), diameter measured by using Vernier scale, soluble solids measured by using PR-32 Digital Sugar Meter (ATAGO, Tokyo, Japan), titratable acids determined by using sodium hydroxide, soluble sugars determined by using the anserine colorimetric instrument (Shanghai Eon Chemical Technology Co., Shanghai, China), Vitamin C content measured by using redox titration with dichloroisocyanol, and the soluble proteins examined by using Coomassie brilliant blue G-250.

Transpiration and irrigation volume treatment

The crop growth, air temperature, solar radiant intensity, and air relative humidity have been proved to be the main influencing factors of cherry evapotranspiration. When irrigating greenhouse cherries, attention should be paid to the characteristics of cherries that are afraid of drought and waterlogging. Excessive or insufficient irrigation will have an adverse impact on their yield. Therefore, it is necessary to calculate the optimal irrigation time and amount based on their transpiration. The net photosynthetic and transpiration rate, stomatal conductance, and intercellular CO_2 concentration of cherry trees were measured by using a Li-6400 photosynthetic instrument (Li-Cor Inc, Lincoln, Nebraska, USA). The Penman-Monteith (PM) method was used to calculate the daily reference crop transpiration as equation 1 with high calculation accuracy and complete theoretical basis.

$$ET_0 = \frac{0.408\Delta(R_n - G)\gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \quad (1)$$

where ET_0 was the reference crop evapotranspiration intensity. Δ was the slope of the saturated water pressure temperature curve. R_n was the net radiant intensity. G was the soil heat flux. γ was the constant of hygrometer. T was the average temperature. u_2 was the wind speed at two meters from the ground. e_s and e_a were the saturated and actual water pressure. According to the evapotranspiration intensity level calculated by using the PM method, four treatment levels for greenhouse cherry irrigation were determined as irrigating at 80% transpiration (ET1), 100% transpiration (ET2), 120% transpiration (ET3), and 140% transpiration (ET4). In this study, 100% transpiration irrigation treatment was set as a comparative experimental group for irrigation volume measurement.

Measurement of yield and quality of cherry cultivated in greenhouse

The morphologies of leaf and plant were recorded including leaf length, leaf width, petiole length, leaf shape, glandular color and quantity, colors of plant trunk and new shoots, the number of new branches on the extended branch of the central trunk, the number of leaves on each leaf cluster branch, the number of sprouts on each branch, branch formation rate, and the opening degree of the main branch of the trunk. When measuring the leaf and the number of leaves, the regression trend of single leaf area *LA* and leaf length *L* of cherry was a power function as below.

$$LA = 0.728L^{2.024}(R^2 = 0.989) \quad (2)$$

The total leaf area could be further estimated to obtain the leaf area index as:

$$LAI = \sum LA \times d / 10000 \quad (3)$$

where *d* was the planting density (plant/m³). The net photosynthetic rate (P_n), transpiration rate (T_r), stomatal conductance (G_s), and intercellular CO_2 concentration (C_i) of muskmelon leaves were measured by using Li-6400 photosynthetic instrument (Li-Cor Inc, Lincoln, Nebraska, USA). The photon flux density (*PFD*) was set to 1,000 μmol/m²/s, and the temperature range of the blade chamber was controlled at around 25°C. Leaf chlorophyll was measured at equal time intervals by using a chlorophyll meter. Due to numerous changes in soil water potential, the numerical expression was as:

$$\Phi = \Phi_m + \Phi_p + \Phi_s + \Phi_g \quad (4)$$

where Φ was the gross water potential. Φ_m was the matrix potential that attracted soil moisture by the soil matrix, which was positively correlated with soil moisture content. When Φ_m was saturated, it equaled 0. Φ_p was the pressure potential caused by saturation pressure. Φ_s was the solute potential, which was the pressure change caused by soil solute. The gravitational potential, Φ_g was affected by gravity. In saturated soil, the Φ of the soil was calculated by using Equation 5.

$$H = h + Z \quad (5)$$

where *H* was the saturated total water potential. *h* was the underground depth. *Z* was the position relative to the reference plane. In unsaturated soil, Φ was calculated by using equation 6.

$$\Phi = \Phi_m + Z \quad (6)$$

when the pressure potential in unsaturated soil was 0 and Φ_m represented negative pressure potential, Equation 6 was the same as Equation 5. The total hydraulic conductivity of the soil plant system represented the derivative of the total resistance of water in the soil to leaf transport pathway. The water transport in cherry tree trunks was relatively stable. Its hydraulic conductivity was calculated as below.

$$K_t = \frac{Tr}{\Phi_s - \Phi_l - pgh} \tag{7}$$

where K_t was the total hydraulic conductivity. Φ_l was the leaf water potential. *p*, *g*, *h* were water density, gravitational acceleration, and cherry tree height, respectively. After the cherry plant bear fruit, it was necessary to get the weight of each individual mature fruit and calculate the irrigation water volume per plant to evaluate the water use efficiency by using equation 8.

$$WUE = Y / I \tag{8}$$

where Y was the yield of a single cherry tree, and *I* was the irrigation amount for the entire fruiting period. To measure the comprehensive quality of cherries, the membership function method was applied as follows.

$$x(\mu) = (X - X_{\min}) / (X_{\max} - X_{\min}) \tag{9}$$

where $X_{\max}$ and $X_{\min}$ were the max- and min-values of the indicator in all treatments. *X* was the actual measured value of the fruit. $x(\mu)$ was the membership function value of the indicator. The negative correlation indicators such as soluble acids and nitrates were calculated as:

$$x(\mu) = 1 - (X - X_{\min}) / (X_{\max} - X_{\min}) \tag{10}$$

After comprehensive processing of all collected data, a transpiration model was established. The accuracy of the model was verified by using regression estimation standard deviation (RMSE) and relative error (RE) as below.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (OBS_i - SIM_i)^2}{n}} \tag{11}$$

where OBS_i was the measured value of *i*. SIM_i was the simulated value of the *i* model. *n* was the sample size. RE was then calculated as follows.

$$RE = \frac{RMSE}{\frac{1}{n}\sum_{i=1}^{n} OBS_i} \times 100\% \tag{12}$$

The smaller the standard error and relative error value, the higher the validity of the transpiration model.

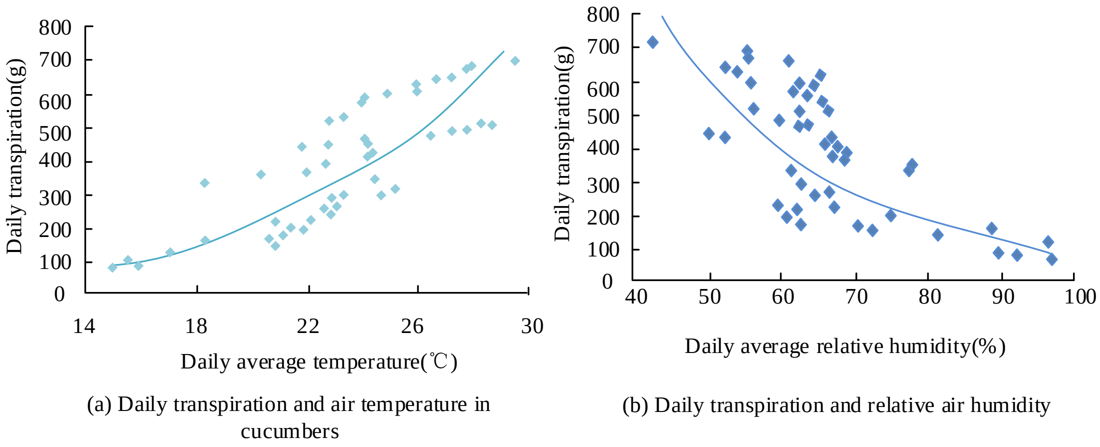
Statistical analysis

SPSS (version 25.0) (IBM, Armonk, New York, USA) was employed for the statistical analysis of this study. Student t-test and ANOVA methods were applied for the detection of differences between various experimental groups. *P* value less than 0.5 was set as the significant difference, while *P* value less than 0.01 was set as the very significant difference.

Results and discussion

The effects of environmental factors on daily transpiration of cherries

Daily transpiration, air temperature, relative air humidity, solar radiation intensity, net photosynthetic rate, transpiration rate, stomatal conductance, and intercellular carbon dioxide concentration were measured in cherry fruit trees. The impacts of environmental factors on the daily transpiration of cherries were shown in Figure 1. The regression analysis results of air temperature and cherry transpiration under greenhouse environment demonstrated that the change trend of greenhouse cherry and daily transpiration and daily average air temperature was a power function with good correlation, while the daily transpiration of greenhouse cherry increased with the daily average air humidity as an exponential function. The higher the daily average air humidity, the lower the daily transpiration of greenhouse cherry. Overall, due to the influence of greenhouse membranes, the humidity of the greenhouse environment was relatively high with daily average relative humidity (RH) of air in the range of 40-70%. During this stage, there was also a period of rapid change in cherry transpiration with daily



(a) Daily transpiration and air temperature in cucumbers

(b) Daily transpiration and relative air humidity

Figure 1. The effects of environmental factors on daily transpiration of cherries.

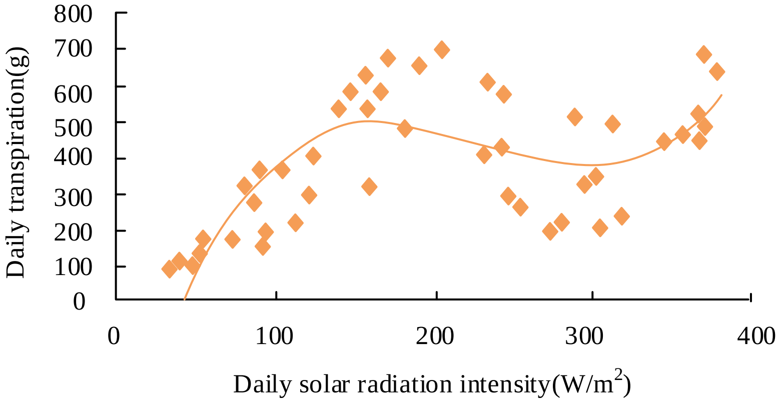


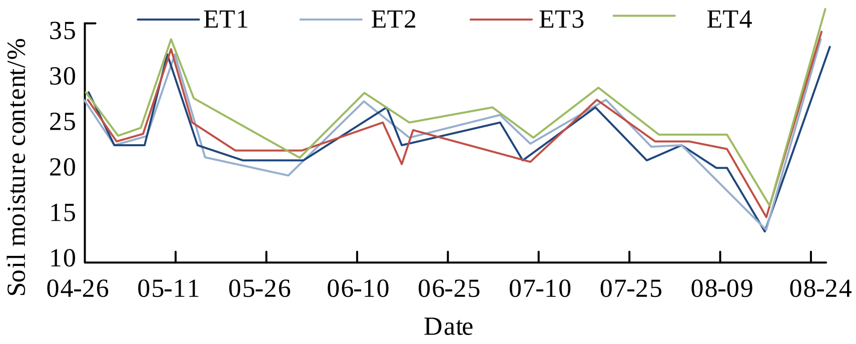
Figure 2. Regression analysis of solar radiant intensity and cherry daily transpiration.

transpiration remaining within 150 g. When the daily average air RH was greater than 80%, cherries could maintain a lower level of transpiration. The regression analysis within the greenhouse environment was shown in Figure 2. The relationship between the daily transpiration of greenhouse cherry and the daily average radiant intensity was a third-order polynomial function. The daily transpiration of cherries increased first and then decreased with the increase of the daily average solar radiant intensity. When the daily average solar radiant intensity was less than 140 W/m^2, the cherry transpiration was highly correlated with the average solar radiation. The daily transpiration was stable at a low level. When the intensity was 140-290 W/m^2, the daily transpiration of cherry changed significantly with the increase of daily average solar radiant intensity, showing a discrete distribution. When the radiant intensity exceeded 290 W/m^2, the fluctuation of cherry daily evaporation gradually decreased. The correlation coefficients between various influencing factors and daily transpiration of cherries were listed in Table 1. The daily average air temperature (T) and the daily solar radiant intensity (M) were significantly positively correlated, while the daily average air relative humidity (ET) was significantly negatively correlated. By comparing the correlation coefficients, T and ET demonstrated the highest correlation. Cherry is an early maturing variety

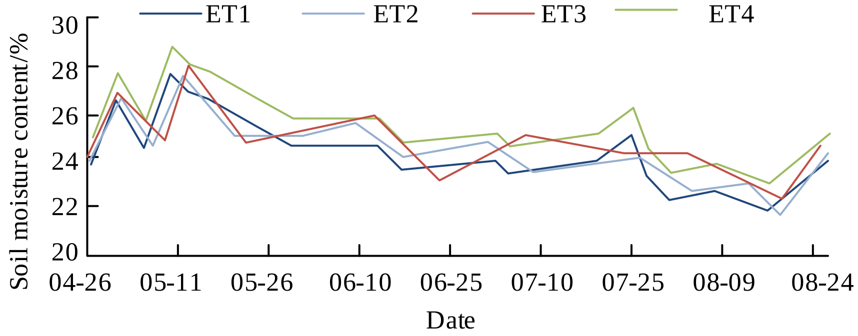
Table 1. Pearson correlation analysis of greenhouse cherry daily transpiration and its influencing factors.

Factors	T	RH	M	ET
LAI	0.56311	-0.5453*	0.2439	0.9109**
T	-	-0.8374*	0.6398*	0.8177*
RH	-0.8374	-	-0.7181**	-0.7197**
M	0.6398**	-0.7181*	-	0.4573**

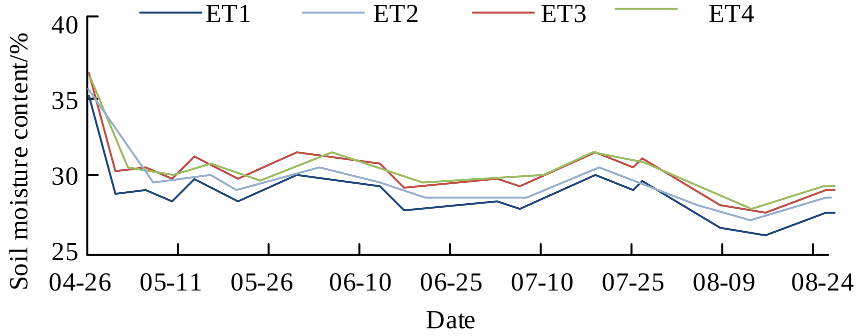
Notes: LAI: leaf area index. T: daily mean temperature (°C). RH: daily mean relative humidity (%). M: intensity of solar radiation (W/m^2). ET: daily transpiration (g). *: $P < 0.05$. **: $P < 0.01$.



(a) 0-20cm Water content of the soil layer



(b) 20-40cm Water content of the soil layer



(c) 40-60cm Water content of the soil layer

Figure 3. Changes in soil moisture contents.

Table 2. Effects of four irrigation treatments on cherry photosynthesis.

Period	Treatment	Net photosynthesis speed ($\mu mol/m^2 \cdot s$)	Stomatal conductance ($mol/m^2 \cdot s$)	Evapotranspiration rate ($mmol/m^2 \cdot s$)	Intercellular carbon dioxide concentration (μmol/mol)
Budding	ET1	17.91	0.21	5.88	246.74
	ET2	21.67	0.31	5.85	279.47
	ET3	25.96	0.56	5.90	335.16
	ET4	23.53	0.43	5.37	320.53
Flowering	ET1	19.33	0.34	6.24	289.76
	ET2	22.43	0.34	5.79	268.66
	ET3	26.41	0.64	6.19	337.12
	ET4	23.72	0.48	6.46	317.85
Fruiting	ET1	18.84	0.26	5.67	268.17
	ET2	21.40	0.45	5.85	315.88
	ET3	27.83	0.63	6.14	329.37
	ET4	22.87	0.44	6.66	297.94

that bears fruit and rapidly expands from May to June, reaching maturity level in early June, while various environmental factors have the greatest impact on fruit quality. The soil moisture content changes under different irrigation treatment conditions were shown in Figure 3. The soil moisture content changed over the time at the depths of 0-20, 20-40, and 40-60 cm, respectively. Overall, the soil moisture content changed significantly in the 0-20 cm soil layer, while, in the 20-40 cm, the soil moisture content changed slowly and showed a decreasing trend overall, mainly because this layer was the main water absorbing layer for cherry trees. In the 40-60 cm, the soil moisture content remained at a high level. However, the change in amplitude was relatively small with the increase of irrigation amount, as most of the water was absorbed in the first few layers. The more irrigation amount of the three-layer soil, the higher the soil moisture content.

Effects of irrigation volume on cherry quality

The four irrigation volume treatments demonstrated a significant impact on cherry photosynthesis (Table 2). During the budding, flowering, and fruiting stages, as the irrigation amount increased, the net photosynthetic rate and chlorophyll change trend of leaves at each stage were consistent, showing a parabolic pattern of increase during the budding stage, reaching the maximum value during the flowering stage, and then beginning to decline. The overall value during the fruiting stage was higher than that during the budding stage. The overall trend of stomatal conductance was consistent with the changes in both, except for the ET2 treatment. The intercellular CO_2 concentration during the flowering stage was slightly higher than that during the fruiting stage with the lowest during the budding stage. There was no significant difference in transpiration rate among different periods. The net photosynthetic rate during flowering was the highest at 25.96 $\mu mol/m^2 \cdot s$ under ET3 treatment, which was 36.6%, 18.1%, and 10.9% higher than that under other treatments. Chlorophyll was the highest in ET3 treatment with 13.1%, 10.1%, and 3.5% higher than that in other treatments. During this period, the highest stomatal conductance was 0.64 $mol/m^2 \cdot s$ under ET3 treatment. During the fruiting period, the photosynthetic rate, chlorophyll, intercellular carbon dioxide concentration, and stomatal conductance were all the highest at the ET3 treatment. The effect of different irrigation amounts on cherry water potential at different stages was shown in Table 3. Different irrigation amounts demonstrated significant differences in cherry growth. As the substrate water potential increased, the leaf

Table 3. Effects of different irrigation rates on water transport in cherries.

Treatment	Substrate water potential by period			Crown water potential by period		
	Budding	Flowering	Fruiting	Budding	Flowering	Fruiting
ET1	-0.15	-0.25	-0.38	-1.21	-1.38	-1.68
ET2	-0.08	-0.19	-0.27	-1.08	-1.34	-1.50
ET3	-0.05	-0.10	-0.17	-0.79	-1.12	-1.32
ET4	-0.02	-0.06	-0.09	-0.62	-0.86	-1.13

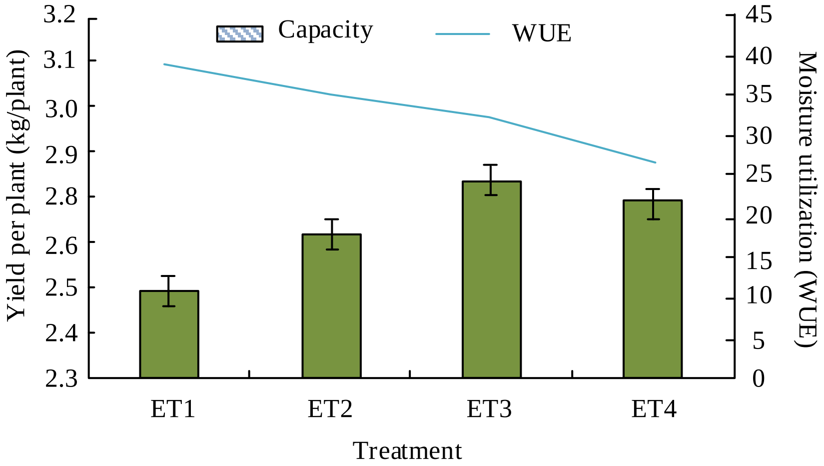


Figure 4. Effect of different irrigation treatments on cherry yield and water use efficiency.

water potential showed an upward trend. From the budding stage to the fruiting stage, the changes in substrate water potential and leaf water potential were consistent, showing a downward trend under all treatments. The leaf water potential and substrate water potential during the budding stage of ET4 treatment were the highest with the values of -0.064 and -0.02 Mpa, respectively, while the ET1 treatment had the lowest values of -1.70 and -0.35 Mpa, respectively. During the same growth period, as the irrigation amount increased, both the substrate water potential and leaf water potential demonstrated an upward trend. The significant differences in cherry yield among different irrigation treatments were observed in this study (Figure 4). As the irrigation amount increased, cherry yield showed a trend of first increasing and then decreasing with the highest yield in ET3 irrigation and the lowest yield in ET1 treatment. The cherry yield of ET3 treatment was 2.83 kg/plant, which was 23.9%, 11.1%, and 3.2% higher than that in ET1, ET2, and ET4 treatments, respectively. The water use efficiency of cherries was determined by the combined influence of irrigation amount and crop yield. Under greenhouse conditions with the only change of irrigation amount, the water use efficiency of cherries decreased with the increase of irrigation amount. The water use efficiency reached the highest at 39.6 kg/m^3 in ET1 treatment, while the lowest irrigation water use efficiency reached 26.9 kg/m^3 in ET4. With the different irrigation amount treatments, there was no unified trend observed in each indicator, so that it was not possible to determine the quality of cherry fruit solely from indicator analysis. Therefore, considering the comprehensive effect of different irrigation treatments on cherry quality, the membership function method was used to calculate the scores of different indicators under each treatment and obtain the comprehensive membership function value of cherry fruit quality. As the irrigation amount increased, the

Table 4. Effect of different irrigation levels on cherry fruit quality.

Treatment	Soluble solid (%)	Soluble acid (%)	Sugar/acid	Vitamin C (mg/g)	Soluble protein (mg/g)	Soluble sugar (%)	Nitrate nitrogen (μg/g)	Attaching Functional valve
ET1	12.10	0.74	16.28	12.23	4.61	7.09	384.91	3.34
ET2	13.13	1.05	12.51	13.05	5.39	7.62	415.40	3.45
ET3	12.87	0.87	14.79	12.87	5.82	7.33	397.61	4.69
ET4	12.43	0.93	13.29	13.96	4.98	6.81	430.64	2.27

comprehensive quality of cherry fruit tended to increase at first and then decreased. The ET3 treatment had the best comprehensive quality of fruit with a membership score of 4.69, while the ET4 treatment had the lowest total fruit quantity and quality (Table 4).

Transpiration is a period in which water is lost into the atmosphere in the form of water vapor through pores, lenticels, and stratum corneum. Unlike evaporation in physics, transpiration is influenced by external environmental conditions. Meanwhile, it is also regulated and controlled by the plant itself. The main process of plant transpiration follows the pathway starting from soil moisture, and then through root hairs, root ducts, stem ducts, leaf ducts, stomata to the atmosphere. When plants are in the seeding stage, all surfaces exposed to the air can be transpiration. The characteristics of plants mainly affect leaf transpiration. Stomatal conductance and boundary layer conductance jointly regulate leaf transpiration. There are three pathways for water movement in this process including co plastid pathway, vacuole pathway, and extracellular pathway. Plants generate transpiration tension during the transpiration process, which affects the transpiration rate of leaves and plants, and is influenced by local meteorological feedback from the leaves. Environmental factors such as air humidity, temperature, soil moisture content, light, wind speed, *etc*. interact with each other, jointly affecting plant transpiration [11, 12]. The transpiration is affected by plant growth, and cherry trees require a large amount of water during the growth period of new branches, flower bud differentiation, and fruit enlargement. The reduction of cherry tree canopy and meteorological factors such as solar radiation and temperature will also reduce its water consumption. In addition to calculating transpiration and determining irrigation based on transpiration models, it is also necessary to consider the impact of environmental factors on plant growth. In the process of plant growth, environmental recorders should be used to monitor and record the air temperature, air relative humidity and solar radiant intensity in the greenhouse.

Conclusion

To optimize the cherry irrigation strategy, improve the cherry yield and quality, and thus improve the economic benefits of cherry, this study compared the effects of different irrigation volume treatments on cherry yield and fruit quality considering the transpiration effect. The results showed that different irrigation amounts based on the transpiration model had a significant effect on cherry growth and development. With the increase of irrigation amount, cherry growth showed a trend of slow-fast-slow with the best fruit quality obtained at the irrigation volume determined by 120% of the transpiration amount. However, the lowest total fruit quality and quality were obtained in the irrigation treatment of 140% of the transpiration amount. The study successfully determined the effects of transpiration patterns and irrigation on yield and quality of greenhouse cherries through quantitative analysis. The results of this study could be important guidelines for efficient and sustainable production of greenhouse cherries, which not only helps agricultural producers to make more scientific decisions, but also may have a positive impact on agricultural water management.

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