Water-Landscape-Ecological Relationship and the Optimized Irrigation Strategy for Green-Roof Plants in Beijing, a Case Study for Euonymus japonicus

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Water-Landscape-Ecological relationship and the optimized irrigation strategy for green-roof plants in Beijing, a case study for Euonymus japonicus

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Abstract. Canbon sequestration and O2 release due to the rapid development of urban greenland could be beneficial for the global implementation of energy saving and CO2 emission reduction, however, this poses another question that increased the demand for irrigation becomes a concern for the sustainable utilization of water resources, especially for Beijing, with the scarcity of land and water resources for Greenland. E.japonicus, as one of typical green -roof plants, has the advantages of alleviating the effect of heat island and improving microclimate environment. However, it needs to make clear that how the physiological performance of E.japonicus treated with different water stresses including full irrigation (CK) (90%-100%FC), low water stress (LWS) (75%-85%FC), moderate water stress (MWS) (65%-75%FC), and serious water stress (SWS) (50%-60%FC) is, and landscape function and ecological serves function are also considered as integrated indicators to selecting optimization irrigation strategy in this study. The results showed that the photosynthetic rate, transpiration rate, stomatal conductance and water use efficiency of E.japonicus were in the order of LWS>MWS>SWS in three treatments of water stress. Moreover, the photosynthetic rate, transpiration rate, stomatal conductance and water use efficiency under LWS were 1.55%、3.3%、4.13%、7.1% higher compared to CK, respectively. Higher leaf area and chlorophyll content were also measured under the treatment of LWS. In terms of ecological serves function, carbon sequestration and oxygen release, and cooling and humidity were lessening with the soil moisture reducing which express the positive correlation relationship. but the differences was no significant.The LWS(75%-85%FC) stimulated the growth of E.japonicus, and effectively regulated the distribution of the assimilation object to chlorophyll and that for the growth of leaves. Besides, it played a significant role in ecological environment. Therefore, the LWS (75%-85%FC) is the optimal water-saving irrigation model.

Key word: green-roof landscape function, ecological serves function, the optimal irrigation model

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1 Introduction

The development of the world economy and urbanization resulted in increasing carbon dioxide emissions annually, which further caused global warming (King, C.D., 1995). Based on this serious problem, it is urgent to implement energy saving, reduce CO_2 emission, take the path of low carbon economy, and develop low carbon cities. Greenland has important self-purification capacity in the urban ecosystem, which is not only the primary producer of the urban ecosystem, but also the regulator of the ecological balance in the urban ecosystem. Greenland of certain quantity and quality could not only beautify the urban landscape and city appearance, but also serve as effective means of reducing and purifying the urban environment pollution (Jian-feng Li, 2010; Yang J, 2008; Fujii S, 2005; Yang J, 2005; Jim CY, 2007). With the implementation of global energy-saving, large area of urban Greenland have been developed, which directly resulted in increasing water consumption, the expansion of greenland area, and rocketing energy consumption. However, due to the shortages of water resources, land resources and energy resources in Beijing, the rapid development of Greenland aggravated the serious shortages. The study of green-roof and green plant water-saving could not only save large amounts of water, alleviate the tension of groundwater overexploitation as a result of surface water shortage, reduce the energy consumption by groundwater exploitation, but also to a large extent alleviate the serious problem of scarce usable Greenland in Beijing.

The natural condition is harsh in Beijing. Drought, less rain and larger evaporation cause water deficiency on soil. Green plants has some drought resistance ability. Researchers had done many works on the drought resistance of green plants under different control levels of soil moisture. But these studies mainly concentrated on the growth characteristics of plants (Djekoun, A., 1991; Heckathorn.S.A.,1997; Widodo,W.,2003; Subramanian,V.B.,1990; Wenting Zhang, Meizhi Mu, Huatian Wang. et al.,2009; Caiyuan Wang, Peiling Yang, Lu lu. et al.,2010; Jinmei Zhao, He Zhou, Jicheng Guo. et al, 2007; Wenting Zhang, Fuqiang Liu, Huatian Wang. et al.,2008; Yan Li, 2009). Moreover, farm crops were mainly selected as the objective of their studies, the yield of crops and the quality of fruit were taken as the most concerned indicator. But for of green plants, we focus on their landscape function and ecological functions in the afforestation of cities without regard to the yield of crops and the quality of fruit. Based on this, we must change the fromer idea for green plants irrigation study. Under water stress condition, it is necessary to find an optimal irrigation model by taking the combined effects of water-landscape-ecology into consideration, set up the reasonable soil moisture control level, and therefore provide theoretical basis for city afforestation and its irrigation management.

Therefore, with pot experiments and E.japonicus taken as the measured object, this paper studied the inadequate irrigation model with full consideration of water-landscape-ecology and the physiological response, which provided a theoretical basis for the management of green-roof plants under inadequate irrigation condition.

2 Materials and Methods

2.1 experiment materials

The selected E.japonicus was one of the typical green shrubs in Beijing. The experiment was conducted in College of Water Conservancy & Civil Engineering, China Agricultural University (39°56′N, 116°17′E). The weather of experimental site is a warm sub-humid continental monsoon climate, with the average temperature of 12.8℃,annual effective accumulative temperature of 4500℃, frost-free period of 189d, annual rainfall of 450-650mm, and annual evaporation of 1835.8mm. E.japonicus was transplanted to flower pots in March 2009. Those pots were 26.5cm in height and 35cm in diameter. Three small holes were made at the bottom of the pots in order to maintain the permeability of soil and prevent water accumulating on the pot floor. The soil samples were collected from the experimental field of the China Agriculture University. After air drying and sieving into 2 mm mesh, the soil was packed to a bulk density of 1.35g/cm3, and left 5cm height below the pot top brim to avoid water overflow. The soil weight of each pot was 15.47kg.. During the experiment, the soil moisture condition was controlled by weight method. For better survival rate of E.japonicus, all seedlings were fully irrigated within a month after transplanting, and rooting powder was applied which would help the roots grow rapidly.

2.2 experiment design

The experiment was designed by four soil moisture condition treatments with six replications: Full irrigation (90%-100%FC), Light water-stress (75%-85%FC), Middle water-stress (65%-75%FC), Severe water-stress (50%-60%FC). During the experiment process, with climate changes, the plants were irrigated to upper limit in every treatments when the soil moisture reached the lower limit of setting beforehand or was close to the lower limit. and made the soil moisture maintain between upper limit and low limit every treatment. For the sake of accuracy, water was irrigated by using the beakers of 400ml and 100ml. Before irrigating, a small tray was put under each pot, so that there would be water leaking from the gap between soil and the pot. Then water seapage was repoured into the pots slowly to ensure appropriate soil moisture for each treatment.

2.3 observation index and measurement method

Leaf area was measured 5 times by vitro method with 30 days interval between consecutive two x measurements. Total 30 leaves were taken from growth well leaves and fixed above the graph paper, then scanned by MRS-2400U2 scanner. The leaf area of scanning leaves was calculated by the AutoCAD software. The growth of leaves was measured by the weighing method in vitro, the whole shrub was divided into three parts: the upper, middle and lower and cut down, then each part leaves were measured the weight with the balance that the accuracy of balance was 0.01g.

The photosynthetic rate (Pn), transpiration rate (Tr), and stomatal conductance (gs) of leaf were measured by the CI-340 photosynthesis system the typical sunny day.was chose between two irrigation and measured once every 2 hours from 8:00-18:00. During the measurement, six leaves were selected from growth well leaves,. according to the different positions of seedlings ,which divided into three parts: the upper, middle and low

We chose the typical sunny day to measure chlorophyll in 10:00am by the SPAD-502 chlorophyll meter which was product in German. During the measurment, five growth well leaves were chose from the top of canopy.

2.4 characterization of landscape function

As green plants of urban, the landscape function was particularly important. The landscape function of green plants mainly embodied in the size of leaves, sparse degree of leaves and leaves color.

Leaf area reflected the size of leaf, calculated as equation(1):

Total leaves area:

$$S_1=S_2\times W_1/W_2 \qquad (1)$$

Where S_1 is the total leaves area, cm^2; S_2 is the leaves area of scanning, cm^2; W_1 is the total fresh weight of leaves, g; W_2 is the leaves fresh weight of scanning, g.

Leaf area index(LAI) reflected the sparse degree of leaves, calculated as equation(2):

Leaf area index(LAI):

$$LAI=S_1/\pi r^2 \qquad (2)$$

Where LAI is the leaf area index; S_1 is the total leaves area, cm^2; r is the average canopy radius, cm.

In this text, leaf color was expressed by chlorophyll content. For evergreen shrub species, the higher chlorophyll content, the better Landscape function.

2.5 characterization of ecosystem service function

2.5.1 Fixing carbon and releasing oxygen

The assimilation of plants enclosed the area of the net photosynthesis and the horizontal axis of time in the diurnal variation curve of plants' photosynthesis.

In this basis, we assumed that the net photosynthesis was P, the formula for calculating the net photosynthesis as follow:

$$P=\sum_{i=1}^{j}[(P_{i+1}+P_i)\div 2\times(t_{i+1}-t_i)\times 3600\div 1000] \qquad (3)$$

Where P is the total assimilation in the sampling day, mmol • m-2 • d-1, Pi is the instantaneous photosynthetic of the measured point, Pi+1 is the instantaneous photosynthetic of the next measured point, $\mu mol\bullet m^{-2}\bullet s^{-1}$; ti is the instantaneous time of the measured point, ti+1 is the instantaneous time of the next measured point, h; j is the times of measuring; 3600 is 3600 seconds every hour; 1000 is 1000 μmol.

The total assimilation converted to amount of fixing CO2:

$$W_{CO2}=P\cdot 44/1000 \qquad (4)$$

Where 44 is molar mass of CO2, g • mol-1,WCO2 is that per unit area of leaf fix CO2 quality, g • m-2 • d-1. According to the reaction equation of photosynthesis:

$$CO_2+4H_2O\rightarrow CH_2O+3H_2O+O_2 \qquad (5)$$

the rate of trees release oxygen is:

$$W_{O2}=P\cdot 32/1000 \qquad (6)$$

Unit is g • m^{-2} • d^{-1}

2.5.2 cooling and humidification

Cooling and humidifier based on the transpiration rate, and the formula for calculating:

$$E=\sum_{i=1}^{j}[(e_{i+1}+e_i)\div 2\times(t_{i+1}-t_i)\times 3600\div 1000] \tag{7}$$

Where E is the total transpiration in the test day, mmol/(m2 • s); ei is instantaneous rate of transpiration of the initial measured point. ei+1 is the instantaneous rate of transpiration of the next measured point $\mu mol/(m^2 \bullet s)$; ti is the instantaneous time of the initial measured point, ti+1 is the instantaneous time of the next measured point, h; j is the period of measuring;

$$W_{H2O}=E\times 18 \tag{8}$$

Where 18 is molar mass of H2O.

We assumed that E.japonicus absorbed heat per square meter leaves in the day as Q, due to transpiration of water, then

$$Q=W_{H2O}\times L \tag{9}$$

Where Q is absorbing heat unit area every day, kJ/(m2 • d); L is evaporation consumption of heat transfer coefficient(L=2495-2.38×t, t is the temperature of measured day).

3 Results and Analysis

3.1 The effect on photosynthetic rate, transpiration rate, stomatal conductance in different controlling level of soil moisture

During the experiment, the photosynthetic rate, transpiration rate and stomatal conductance of different leaves positions of E.japonicus were measured in different time. The results (table 1) showed that there were no negative relation between the photosynthetic rate, transpiration rate stomatal conductance and increasing water content On September.photosynthetic characteristics for MWS treatment (75%-85%FC) were performing better than other treatments, indicating that the differences in the demand for water and the ability to adapt in different time, due to E.japonicus physiological regulation. Transpiration rate showed a single peak along with the solar radiation, temperature, humidity and other climate factors (Fig. 1). Photosynthetic rate showed a single peak in the full water supply, but the photosynthetic rate showed a "lunch break" phenomenon at midday under water stress condition. Stomatal conductance reached the maximum in all treatments in the morning.

Table 1. the effect on the photosynthetic characteristics in different water treatments

Time	parameters	treatments			
		CK	LWS	MWS	SWS
2010	photosynthetic（Pn）($\mu mol \bullet m^{-2} \bullet s^{-1}$)	4.40±1.63a	4.34±1.33a	4.03±1.39a	3.36±1.35b
	Transpiration（Tr）（$mmol/m^2/s$）	0.92±0.44a	0.89±0.38a	0.88±0.36a	0.73±0.41b
	Stomatal conductance（Gs）（$mmol/m^2/s$）	33.90±16.1a	32.81±13.95b	32.09±13.22b	25.37±11.07b
	Water use efficiency（WUE）（$\mu molCO_2/mmolH_2O$）	6.16±4.31a	5.31±2.02b	5.14±2.12b	4.98±2.18b
200	photosynthetic（Pn）($\mu mol \bullet m^{-2} \bullet s^{-1}$)	4.51±1.28a	4.44±1.40ab	3.90±0.97b	3.40±1.33c

9			c	
Transpiration（Tr）（mmol/m^2/s）	0.91±0.40a	0.94±0.37a	0.86±0.38ab	0.75±0.33b
Stomatal conductance（Gs）（mmol/m^2/s）	34.36±15.64a	35.78±16.26ab	28.74±9.30bc	26.63±12.49c
Water use efficiency（WUE）（μmolCO_2/mmolH_2O）	5.53±1.98a	5.14±1.84ab	5.07±1.99ab	4.89±1.91b

Data followed by different letters (a, b, c)within same columns at same stage are significantly different at $P_{0.05}$ level; values are Mean ± S.E. of each treatment.

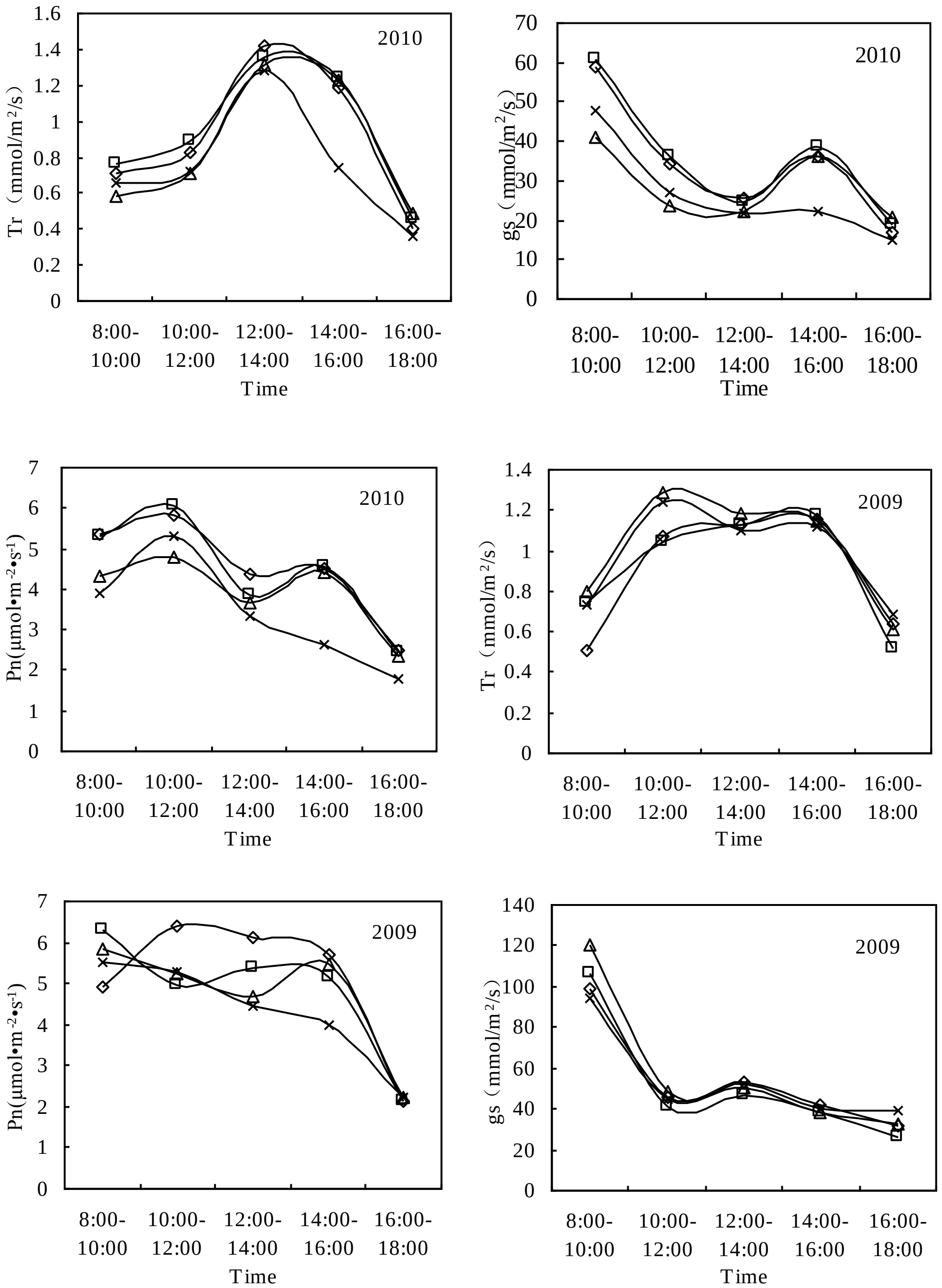


Fig 1. the change process of the photosynthetic rate, transpiration, stomatal conductance in different time

3.2 The effect on landscape function and ecosystem serves function for E.japonicus in different control level of soil moisture

3.2.1 Landscape function

E.japonicus was the typical green plant in Beijing, which played an important role in the beautification of the city. In this paper, we evaluated the landscape function of E.japonicus with four parameters in different control levels of soil moisture, which were leaf area, leaf area index, leaf growth and chlorophyll.

As table 2 shown, leaf area, leaf area index, leaf growth and chlorophyll performanced differently under various control levels of soil moisture. The leaf area, leaf area index, leaf growth and chlorophyll of the SWS treatment were less than other treatments. The result showed that (50%-60%FC) didn't provide enough water of normal growth of E.japonicus. which would restrain the growth of E.japonicus, such as sparse growth of leaves and smaller total leaves area. However, when the soil moisture was (75%-85%FC), leaves growth and the total leaves area were the optimal, suggesting that (75%-85%FC) was the optimal soil moisture for the growth of E.japonicus, meanwhile, leaf growth showed flourish characteristics. The sizes of leaf area and leaf growth of the mid and low part of E.japonicus were quite important for appreciation as the green plants. Small and sparse leaf had an apparently impact on the landscape function of E.japonicus.

Table 2 the parameter of landscape function in different treatment

parameter		treatment			
		CK	LWS	MWS	SWS
The total leaf area（cm^2）		951.84±73.64b	1026.14±71.85a	898.17±36.16bc	841.96±79.32c
Leaf area index		0.24	0.44	0.43	0.28
Amount of leaf growth（g）	up	53.18	73.04	48.08	46.68
	mid	109.78	127.92	123.53	45.03
chlorophyll (SPAD)		67.6±3.6b	75.4±5.4b	68.0±2.9a	65.2±2.4a

Data followed by different letters (a, b, c)within same columns at same stage are significantly different at $P_{0.05}$ level; values are Mean±S. E. of each treatment.

3.2.2 Ecological effects

The amount of carbon fixation and oxygen releasing, cooling and humidification of E.japonicus were showed in Table 3 under different treatments. We could see differences which was not significant each treatment through the variance analysis for data. Through comparing between different treatments, In 2009 and 2010,the amount of carbon fixation of the CK treatment is higher 8.68%,10.53%,17.93% and -1.42%,8.59%,30.21% than LWS,MWS,SWS treatment respectively; the amount of oxygen releasing of the CK treatment is higher 8.72%, 10.75%, 17.91% and 0.24%,10.48%,32.15% than LWS,MWS,SWS treatment respectively；the amount of cooling of the CK treatment is higher -0.83%,5.94%,7.13% and 4.19%,4.54%,25.95% than LWS,MWS,SWS treatment respectively; the amount of humidification of the CK treatment is higher -0.82%、5.94%、7.13%和 4.19%、4.54%、

25.95% than LWS,MWS,SWS treatment respectively; From data what mentioned above,the ecological of E.japonicus is lessening with the soil moisture reducing.

Table 3 The effect of ecosystem in different control levels of soil moisture

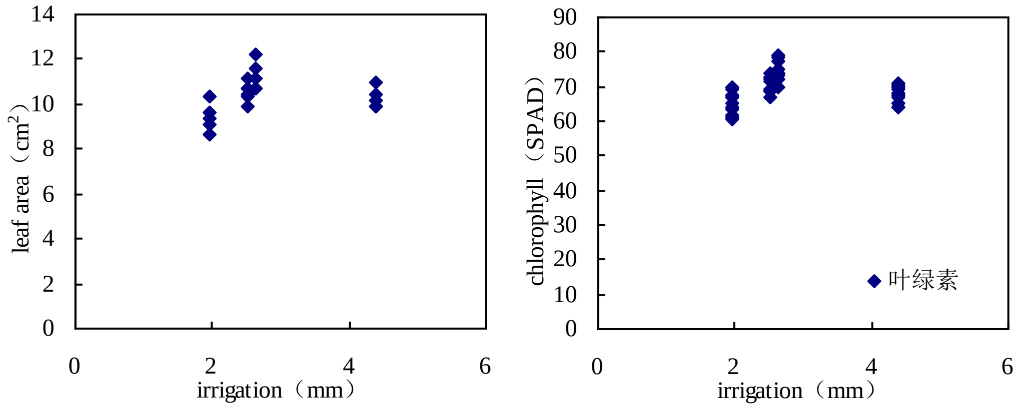
Time	parameters	treatments			
		CK	LWS	MWS	SWS
2010	Carbon fixation ($g \cdot m^{-2} \cdot d^{-1}$)	5.56±1.06a	5.64±0.27a	5.12±0.84a	4.27±0.49b
	Oxygen release ($g \cdot m^{-2} \cdot d^{-1}$)	4.11±0.77a	4.10±0.2a	3.72±0.61a	3.11±0.36b
	Humidification [$mg/(m^2 \cdot s)$]	522.79±85.03a	501.77±27.91a	500.11±58.05a	415.08±73.56a
	Cooling ($J/(m^2 \cdot d)$)	1272.55±206.98a	1221.38±67.94a	1217.34±141.38a	1010.36±179.04b
2009	Carbon fixation ($g \cdot m^{-2} \cdot d^{-1}$)	6.51±0.83a	5.99±2.04a	5.89±1.74a	5.52±1.36a
	Oxygen release ($g \cdot m^{-2} \cdot d^{-1}$)	4.74±0.60a	4.36±1.49a	4.28±1.27a	4.02±0.99a
	Humidification [$mg/(m^2 \cdot s)$]	545.15±121.76a	549.68±150.65a	514.58±123.22a	508.86±36.58a
	Cooling ($J/(m^2 \cdot d)$)	1328.68±296.76a	1339.74±367.19a	1254.19±300.33a	1240.24±89.14a

Data followed by different letters (a,b,c)within same columns at same stage are significantly different at $P_{0.05}$ level;values are Mean±S.E.of each treatment

3.3 The relation of water-landscape-ecolog ical

3.3.1 the relation between water and landscape

Leaf color and size of leaf area of green plant were particularly important for appreciation. The paper analyzed the relation between leaf area and water, chlorophyll and water (Fig 2). The result showed that leaf color and leaf area of E.japonicus had a high relationship with soil moisture. There was not a linear relation between Chlorophyll content and leaf area. Whe the soil was too wet or too dry, it was bad for the growth of E.japonicus, which affected the landscape function of E.japonicus.



（a）the relation of water and chlorophyll （b）the relation of water and leaf area

Fig 2 The relation of water and landscape

3.3.2 the relation between water and ecological

The ecological effects of E.japonicus under different water control level of soil moisture were obtained by calculating the amount of carbon fixation and oxygen release, cooling and humidification of E.japonicus. As Fig. 3 shown, carbon sequestration and oxygen release, and cooling and humidity were lessening with the soil moisture reducing which express the positive correlation relationship. but the differences was no significant The results showed that the increasing or decreasing the amount of irrigation didn't produce fundamental influence on ecological service function.

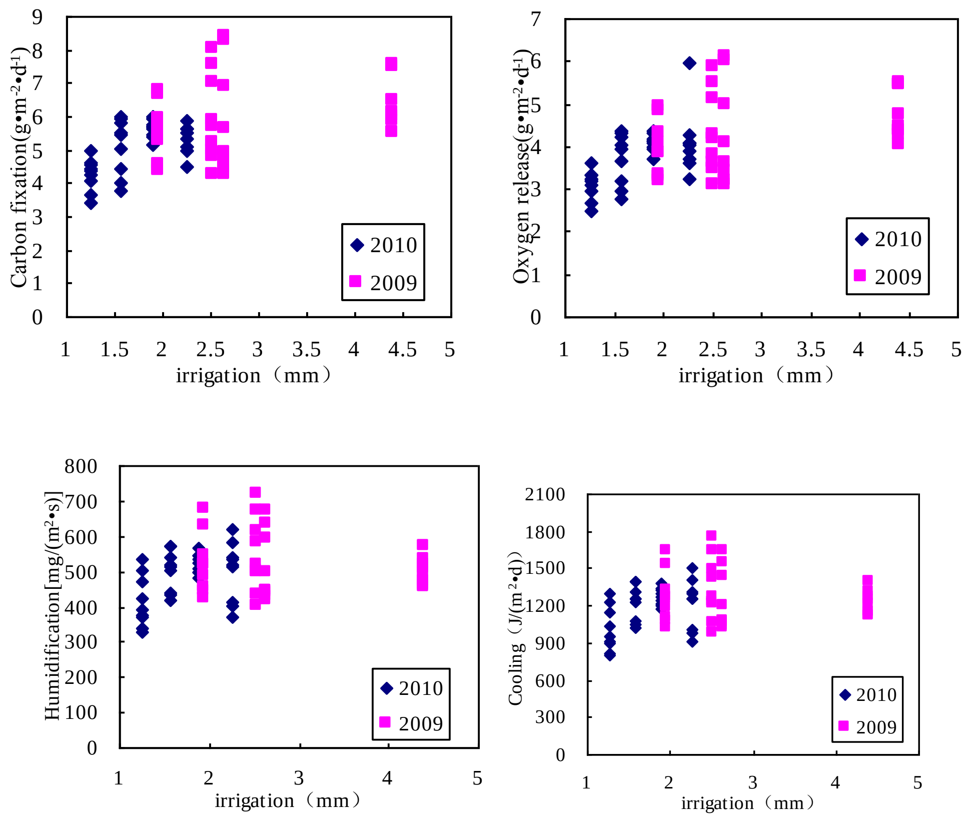


Fig 3 the relation of water and ecological

4 Discussion

As the regulator of ecosystem, Greenland plays the role of improving the urban environment in the urban landscape, as well as beautifying the urban area(Nowak DJ, 2006). The global implementation of energy saving and CO2 emission reduction gave impetus to the rapid development of urban Greenland. The rapid development of Greenland largely aggravated the shortages of water resources, land resources and energy resources. In this paper we studied the relationships between water and landscape, between water and ecological function under different soil water stress conditions and the reasonable control level of soil moisture, which had great significance for alleviating the serious shortage of water resource and energy resource, constructing low-carbon city, and protecting the ecological environment.

The results showed that the optimal soil moisture was (75%-85%FC) (FC means field capacity). The conclusion could be explained by landscape function and ecological service function: As for the landscape function, in this study, leaf area, leaf growth and chlorophyll content were used as the measuring standardfor landscape functions of E.japonicus with leaf area reflecting the size of plant leaves, Leaf blade growth increment reflecting the extent of the growth sparse,and Chlorophyll content reflecting the green degree of leaves. By measuring the leaf area, leaf growth and chlorophyll, we analyzed the landscape features of E.japonicus with different control levels of soil moisture. The research showed that leaf growth, leaf area and chlorophyll of E.japonicus were inhibited in serious water stress. It also showed that the serious water stress could not meet the need of water for E.japonicus'sself-growth and exceeded its self -bearing capacity, causing the "dwarf" phenomenon of leaf growth with the yellow-green color. The growth of E.japonicus was better with the soil moisture of (75%-85%FC) than the case under othertreatments .The result showed that in order to gain growth E.japonicus made necessaryadjustment in terms of soil moisturethrough its own physiological regulation system, which synthesized extremely full nutrients for self-growth. Besides, leaf growth, leaf area and chlorophyll content reached the optimal level, which made the landscape function was sufficiently realized as the typical urban green shrub species. In the ecological aspect, this study used carbon fixation and oxygen releasing, cooling and humidification of E.japonicus as the measurement criteria. By analyzingcarbon fixation and oxygen releasing, cooling and humidification, the result showed that there were no significant differences in carbon fixation and oxygen releasing, as well as in cooling and humidification with different control levels of soil moisture. The phenomenon showed that E.japonicus assigned more nutrients from soil absorbing to the photosynthetic mechanism through self regulation under water stress condition, so that it maintained better ability of absorbing CO2.

This study also showed that the stomtal conductance was the largest in the morning for different treatments by analyzing the photosynthetic rate, transpiration rate and stomtal conductance of different leaf position. The explanation of the phenomenon was as follows: due to self-regulation of E.japonicus, the physiological activity was weaker at night. After a night's "sleep", with supplying its own body with the needed nutrientsand it exchanged with outside and the channel of the exchange was stomatal. So the stomatalopened larger. Jiachou Chen and Yongqiang Zhang obtained similar conclusions, who studied peanuts and wheat (CHEN jiazhou, 2005; Zhang YQ, 2001). This study provided further evidence for the fact that the stomatalconductance are abnormally large in the morning. Photosynthetic rate showed a downward trend in the morning, and sustained low at noon, but the decline was slowdown. The explanation of the phenomenon was as follows: The serious water stress caused photosynthetic rate to decrease significantly, which may be caused by non-stomatal factors. Leaf had higher intercellular CO2 concentration, which caused the disruption of respiratory system, and therefore resulted in the physical activity decreasing, hindering the transportation and distribution of photosynthetic products, and finally showed the photosynthetic rate decreasing. The solar radiation was quite strong at noon, when the leaves captured the excitation energy to exceed carbon assimilation capacity. The extra light energy was dissipated, causing light energy utilization efficiency low and made photosynthetic rate decrease (Muller P, 2001). On the other hand, temperature and photosynthetic rate were positively correlated in a certain temperature range.With the rise of temperature, the photosynthetic rate also rises. The optimal activation temperature of the key enzyme Rubisco of photosynthetic was 25~30℃, which activity directly affected photosynthesis (Salvucci M E,1986). When the leaf temperature was over-high, it was detrimental to their photosynthesis. Light and temperature conditions affect the supply of soil moisture, which also plays an important role in controlling leaf gas exchange (Yang C,1998). This also explains why photosynthesis appeared the rising trend in the afternoon.

As this study was related to the physical aspects of plants and E.japonicus was evergreen shrub,We could not have a very in-depth study in a short time and recommended a long-term observation for the typical shrubs speciesto the further understand the landscape function and ecosystem service function of urban greening plants. In the study, there were other limitations. we only chose clear days to measure the landscape function and ecosystem service function, but it is recommended to measure the landscape function and ecosystem service function according to different weather conditions (clear days, cloudy days, rainy days).

5 Conclusion

（1）In the vegetative nutrition growth and physiological control aspect, the LWS (75%-85%FC) caused the water-deficit on the plant root, adjusted photosynthetic products to allocate to different tissues and organs to improve the growth and physiological characteristics of E. japonicus. In the process of water use controlling aspect, the LWS (75%-85%FC) induced the protection mechanism of E.japonicus leaves, reduced plant water consumption of luxury and improved water use efficiency under the no obvious reduction of photosynthetic rate condition.

(2) In the Landscape function aspect, landscape feature and leaf area, leaf growth, chlorophyll content of E.japonicus showed a positive correlation. Larger leaf area, the more lush leaf growth and higher chlorophyll content , green plants performance the better landscape functions. (75%-85%FC) stimulated the growth of E.japonicus, adjusted the roots to absorb nutrients from the soil in the regulation of plants. Through measuring and studying leaf area, leaf growth and chlorophyll , based on the consideration of agricultural water-saving and landscape features, (75%-85%FC) was the optimal soil moisture

(3) In the Ecological benefits aspect, carbon sequestration and oxygen release, and cooling and humidity were lessening with the soil moisture reducing which express the positive correlation relationship. the ecological effect of E.japonicus was not obvious under different control levels of soil moisture, different treatments did not show a significant difference. Based on consideration of agricultural water-saving and ecological benefits, we could be considered that the optimal soil moisture content was (75%-85%FC).

Therefore, the research based on comprehensive consideration of agricultural water-saving, landscape features, ecological benefits. Preliminary view was that the LWS (75%-85%FC) was the optimal irrigation pattern of E.japonicus.

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