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不同水分处理对日光温室黄瓜多胺与激素的影响

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摘要：研究了不同土壤含水量对日光温室黄瓜生长与物质代谢的影响，结果如下：冬春茬各生育期随着土壤水分的减少，不同处理的叶片数、叶面积、株高、节间长均降低。水分亏缺初期，叶片脯氨酸含量随着土壤含水量的降低而增加，随着时间延长此趋势消失。盛瓜期 Pro 含量以 T1 最多，达 17.95μg/gDW，分别是 T2 与 T3 的 2.0 倍与 2.4 倍；末瓜期各处理的 Pro 含量均达最高值，T1、T2、T3 分别为 25.30、15.60、12.33μg/gDW，秋冬茬叶片脯氨酸含量变化规律同冬春茬。无论冬春茬还是秋冬茬，游离蛋白质的变化规律同脯氨酸。叶片亚精胺（Spd）与腐胺（Put）含量随着土壤水分的减少而增加。不同水分处理对黄瓜叶片精胺（Spm）含量的影响不大。根系中 Spd、Put、Spm 的变化趋势同叶片。冬春茬不同水分处理的黄瓜叶片 ABA 含量均随着土壤含水量的减少而增加。

关键词：水分处理；日光温室；黄瓜；激素与多胺

Effect of water treatments on ABA and polyamine content of cucumber growing in solar greenhouse

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Abstract: The growth and metabolization of cucumber under the solar greenhouse were investegated, the results were as followed: During the autumn-winter season, cucumber height, leaf number, and leaf area decreased as the soil water content decreased, the growth of cucumber was reduced. At the beginning of the treatment during the autumn-winter season, the proline content, free protein content in the T1 (soil moisture was 85%～90% of field capacity) was significantly lower than that of the other two stressed treatments. As time prolonged, the trend disappeared. At the flourish fruit stage, the proline contents in the T1 was the highest among the treatments, that was 17.95μg/gDW, which doubled T2 (soil moisture was 70%～75% of field capacity) and, 2.4 times T3 (soil moisture was 55%～60% of field capacity). At the last fruit stage, the proline variation was similar to that of the flourish fruit stage. The proline content during winter-spring season followed the same trend as autumn-winter season. Whether it was during winter-spring season or during autumn-winter season, the protein variation is the same as proline. At the beginning of treatments during the autumn-winter season, the leaf Spd content in T3 was higher than that in T2 or T1. As for Put, the variation appeared in order as T3＞T2＞T1. However there was no significant difference of Spm among the treatments. During the winter-spring season, the variations of leaf Spd, Put and Spm was the same as that of autumn-winter season. Though the contents of the three polyamines in the root were lower than that in the leaf, the variation trends in root were the same as that of leaf. At the initial fruit stage during the autumn-winter season, ABA content in T3 was higher than that in the treatments T1 or T2, there was no significent difference between T1 and T2. The ABA content trend in the three treatments appeared in order as T3＞T2＞T1 at the last fruit stage. With respect to the winter-spring season, the leaf ABA contents of the three treatments were much higher than that of the autumn-winter season, the trend remained as T3＞T2＞T1.

Key words: cucumber (*Cucumis sativus* L.); soil moisture; osmotic regulation; ABA

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Water supply was one of the most common limiting environmental factors for plant growth, which would ultimately affect the production and yield of crops[1]. Water deficit led to numerous physiological changes, such as altering root to shoot ratio, reducing leaf area or leaf number, declining LAI(leaf area index)[2]. Also, the stomata function[3], stomata number per leaf area and stomata guard cell aperture were affected[4~6]. In wheat, during long-term water stress, osmotic adjustment(OA)was increased while the water stress aggravated at joining and flowering stage, but that was decreased at the milking stage while the grains were being filling and the OA was increased when the spine was removed at the same stage[7]. The influence of water stress on the photosynthetic adaptability of cucumber growing under solar greenhouse have been studied by Wang[8]. Cucumber was very sensitive to water. In the solar greenhouse there was no rainfall to the beds. Therefore irrigation management was one of the key factors to determine plant growth and development[1]. Since there was little studies on osmotic adjustment of cucumber growing in solar greenhouse, this research had been conducted to examine cucumber growth and osmotic adjustment under different water treatments, which will benefit the understanding of the resistance mode of cucumber on stress, and bring out the scientific irrigation management for cucumber growing in solar greenhouse.

1 Material and methods

The experiment was conducted at China Agricultural University, Beijing, China. Cucumber seeds were provided by Tianjin Vegetable Institute, Tianjin, China.

Cucumber seeds were germinated in plastic pot(10cm×10cm)with a vermiculite and peat mix on Oct. 1,1998 and on Feb. 1,1999 respectively. Two weeks later, seedlings each with three leaves were transplanted into 30cm×40cm clay pots with 5.5 kg fertile alluvial soil (the soil moisture, soil moisture at field capacity, and field capacy are 9.78%, 22.65%, and 32.36%, respectively). Two seedings were in each pot and all pots were placed under the solar greenhouse. After another week, the transplanted seedlings were thinned to one per pot. And the following treatments were implemented, i.e.: watered to 85%~90% of field capacity(T1, as the control)and, maintained at 70%~75% of field capacity(T2)and, at 55%~60% of field capacity(T3). An ramdomized completely block design was employed in this study and there were three blocks with 10 pots per block per treatment. Under each block, pots were randomized placed. All pots were fertigated with Holland nutrients (the pH was 7.2 and, EC was 2.3mS/cm), and weighed everyday to ensure that they stayed within the treatments mentioned above. Weight adjustments were made individually by adding nutrient solution. Day /night temperature during the experiment were 23±3℃/15±3℃.

During initial fruit stage, flourish fruit stage, and last fruit stage, proline (Pro) and free protein(Pr) contents were measured respectively with 10~15 discs collected from the latest, fully expanded leaves from different plants, the leaves were excised with a stiletto, the diameter was 1cm, then the leaf discs were put into a small bottle full of liquid nitrogen with a cover immediately, the method was referring to Wang[9].

The growth of height, node length, leaf number, leaf area were measured five times during the whole growth. The leaf area was caculated as followed:

$$\text{Leaf area} = 0.8 \times \text{leaf length} \times \text{leaf width}$$

The measurement of polyamine content was following to Wei[10] and, ABA content was detected by ELISA method[11].

2 Results

2.1 Effect of different water treatments on the growth of cucumber

During the autumn-winter season, the height, leaf number, and leaf area of the cucumber decreased as the soil water content decreased (table 1), the growth of cucumber was reduced. The increase of the indexes on T3 was the smallest among the three treatments. During the affluent fruit stage (1998-11-06~1998-11-20), the total leaf area per plant on T1 was increased to 125.0 cm^2, while the total leaf area per plant on T2 and T3 were 103.1cm^2 and 77.5cm^2, respectively. Furthermore the increased leaf area on T1 during winter-spring season at the same affluent fruit stage (1999-04-11~1999-05-05) was larger, for example, the leaf area in Apr. 24 was 1615.3cm^2 per plant, which was as 13 times as that of autumn-winter season in 1998-11-11.

2.2 The proline change

Water availability drastically influenced proline content (Pro.). There were significant differences of proline content among the treatments. At the beginning of treatments during the autumn-winter season, the proline content in T1 was significantly lower than that in any other two stressed treatments (Fig. 1). As the plant growing, the proline content in T1 was higher than that in T2 or T3. At the end of treatments, the proline content in T1 was doubled in T3. The proline content during the winter-spring season followed the same trend as the autumn-winter season.

Table 1 Effect of different water treatments on cucumber growth under the solar greenhouse in different seasons

Season	Growth	Treatment	Date				
			1998-11-06	1998-11-20	1998-11-27	1998-12-04	1998-12-22
Autumn-winter season	Leaf number	T1	8.1a	2.7a	2.0a	1.8non	1.1non
		T2	7.0a	2.1a	1.1b	1.1non	1.0non
		T3	5.7b	1.3b	1.1b	1.0non	0.8non
	Leaf area(cm^2)	T1	770.9a	125.0a	28.0non	18.6a	13.3a
		T2	620.1a	103.1a	25.5non	12.3a	7.5b
		T3	344.1c	77.5b	23.2non	10.2b	6.5b
	Length two nodes (cm)	T1	5.0a	1.9a	0.6non	0.6a	0.57a
		T2	4.1a	1.4a	0.54non	0.4b	0.1c
		T3	3.2b	0.9b	0.33non	0.2c	0.1c
	Height(cm)	T1	40.1a	35.0a	11.8a	6.3a	4.5a
		T2	32.2b	21.1b	7.5a	4.2a	2.9b
		T3	27.3b	17.4c	4.5b	2.8b	1.4b
			1999-04-10	1999-04-24	1999-05-05	1999-05-11	1999-05-18
Winter-spring season	Leaf number	T1	7.3a	6.6a	3.2non	3.2a	3.8a
		T2	6.5a	5.1a	3.3non	2.3a	3.0a
		T3	5.3b	3.4b	2.8non	1.2b	1.7b
	Leaf area(cm^2)	T1	910.4a	1615.3a	1848.0a	865.9a	740.8a
		T2	696.8b	1401.4a	1654.0a	700.2b	768.3a
		T3	342.2c	532.0c	873.6c	676.1b	452.5b
	Length of two nodes (cm)	T1	5.4a	1.7a	0.8a	0.7a	0.8a
		T2	4.8b	1.3a	0.8a	0.4b	0.1b
		T3	4.1b	0.7b	0.4b	0.2b	0.1b
	Height(cm)	T1	41.4a	47.2a	31.7a	19.1a	14.0a
		T2	31.3b	39.2a	27.3a	15.0b	11.2a
		T3	23.3c	18.1c	20.9b	14.2b	7.0b

$p<0.05$; non, not statistically significant

2.3 Free protein change

At the beginning of treatments during the autumn-winter season, the free protein content in T1 was lower than that in another two stressed treatments (Fig. 2). One month later, the free protein content in T1 increased to 3.71 mg/g DW. There was no significant difference between T2 and T3. At the end of treatments the free protein content in T1 reached to 5.12 mg/gDW, which was 2.19 times than that in T2 and 2.70 times in T3. The free protein variation in the three treatments during the winter-spring season was the similar to autumn-winter season.

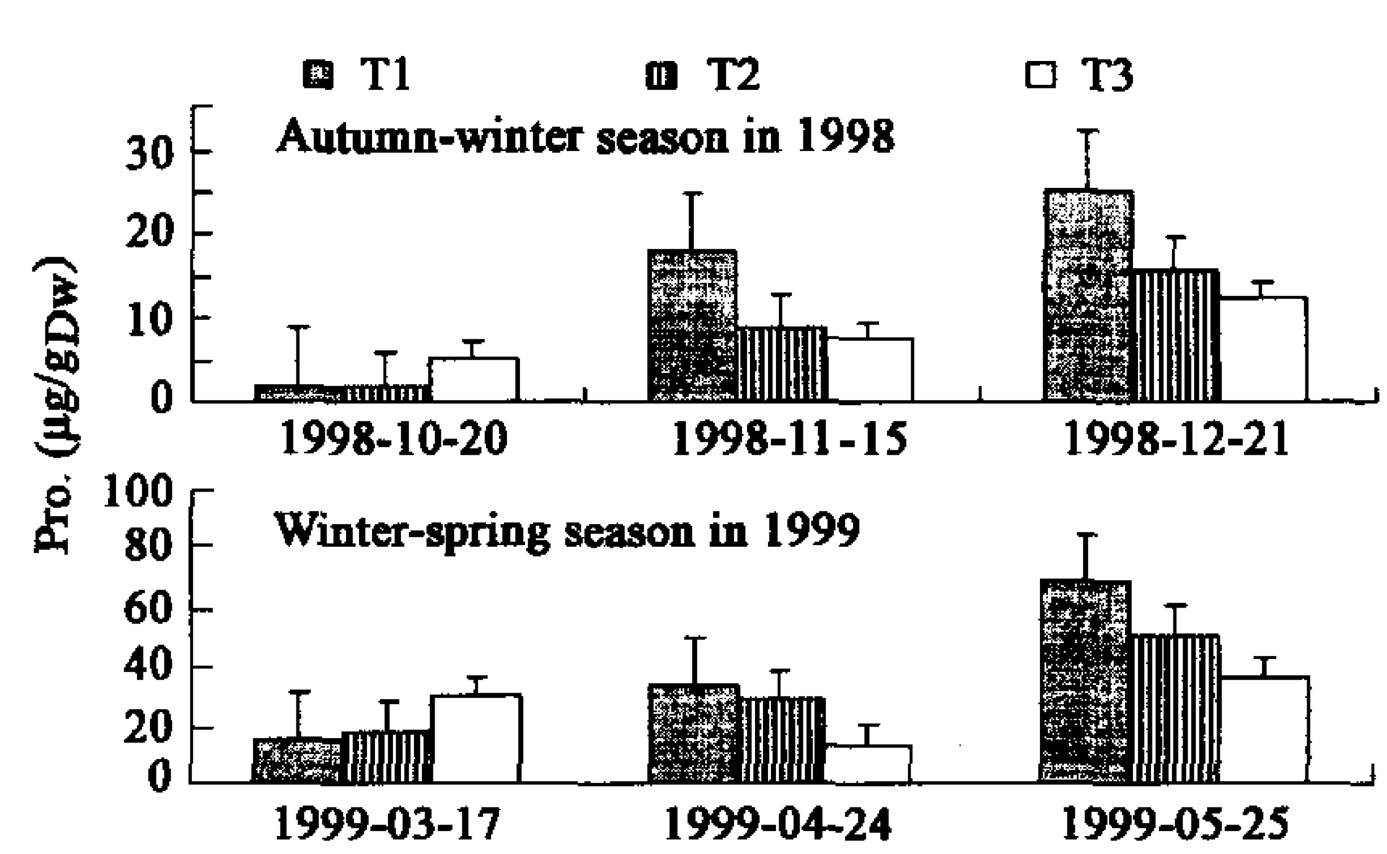

Fig. 1 Effect of different water treatments on proline content of cucumber leaves under the solar greenhouse during different seasons

2.4 Polyamine change

At the beginning of treatments during the autumn-winter season, the leaf Spd content in T3 was 104.75 μg/g DW, which was higher than that in T2 or T1 (table 2). As for Put, the variation appeared in order as T3>T2>T1. However there was no significant difference of Spm among the three treatments. It indicated that Spm was not sensitive to the change of soil moisture. During the winter-spring season, the variations of leaf Spd, Put and Spm was the same as that of autumn-winter season. the change of root Spd, Put and Spm were also observed, it was found that the contents of the three polyamines in the root were lower than that in the leaf, but the variation trends in root in the three treatments were the same as that of leaf.

2.5 ABA change

At the initial fruit stage during the autumn-winter season (1998-11-05～1998-11-25), ABA content in T3 was 42.6 ng/g FW, which was higher than that in the treatments T1 or T2, there was no obvious difference between T1 and T2. During the flourish fruit stage, the leaf ABA content in T3 increased to 757.4 ng/g FW, whereas leaf ABA content in T1 was 409.4 ng/g FW. The ABA content trend in the three treatments appeared in order as T3>T2>T1 at the last fruit stage(Fig. 3).

With respect to the winter-spring season, the leaf ABA contents of the three treatments were much higher than that of the Autumn-Winter season, the trend remained as T3>T2>T1(Fig. 3).

Table 2 Effect of different water treatments on polyamine content of leaves and roots of cucumber under the solar greenhouse

Apparatus	Season	Treatment	Spm (μg/g FW)	Spd (μg/g FW)	Put (μg/g FW)
Leaf	Autumn-winter season	T1	160.78±4.80	57.95±1.80	99.58±4.90
		T2	158.14±4.00	77.84±3.19	120.45±2.76
		T3	159.73±3.30	104.75±2.45	157.08±3.20
	Winter-spring season	T1	150.46±2.21	40.79±1.98	78.06±5.72
		T2	144.29±3.07	69.04±3.33	90.46±2.37
		T3	139.08±3.17	87.45±2.75	121.73±3.12
Root	Autumn-winter season	T1	60.93±4.60	26.49±1.80	45.07±2.75
		T2	63.07±2.02	48.72±2.79	66.74±4.20
		T3	61.75±2.75	69.05±4.78	80.79±3.27
	Winter-spring season	T1	55.79±5.50	19.15±4.49	33.45±3.45
		T2	51.46±2.25	33.87±3.47	47.00±3.47
		T3	66.77±3.94	50.96±2.99	68.99±2.71

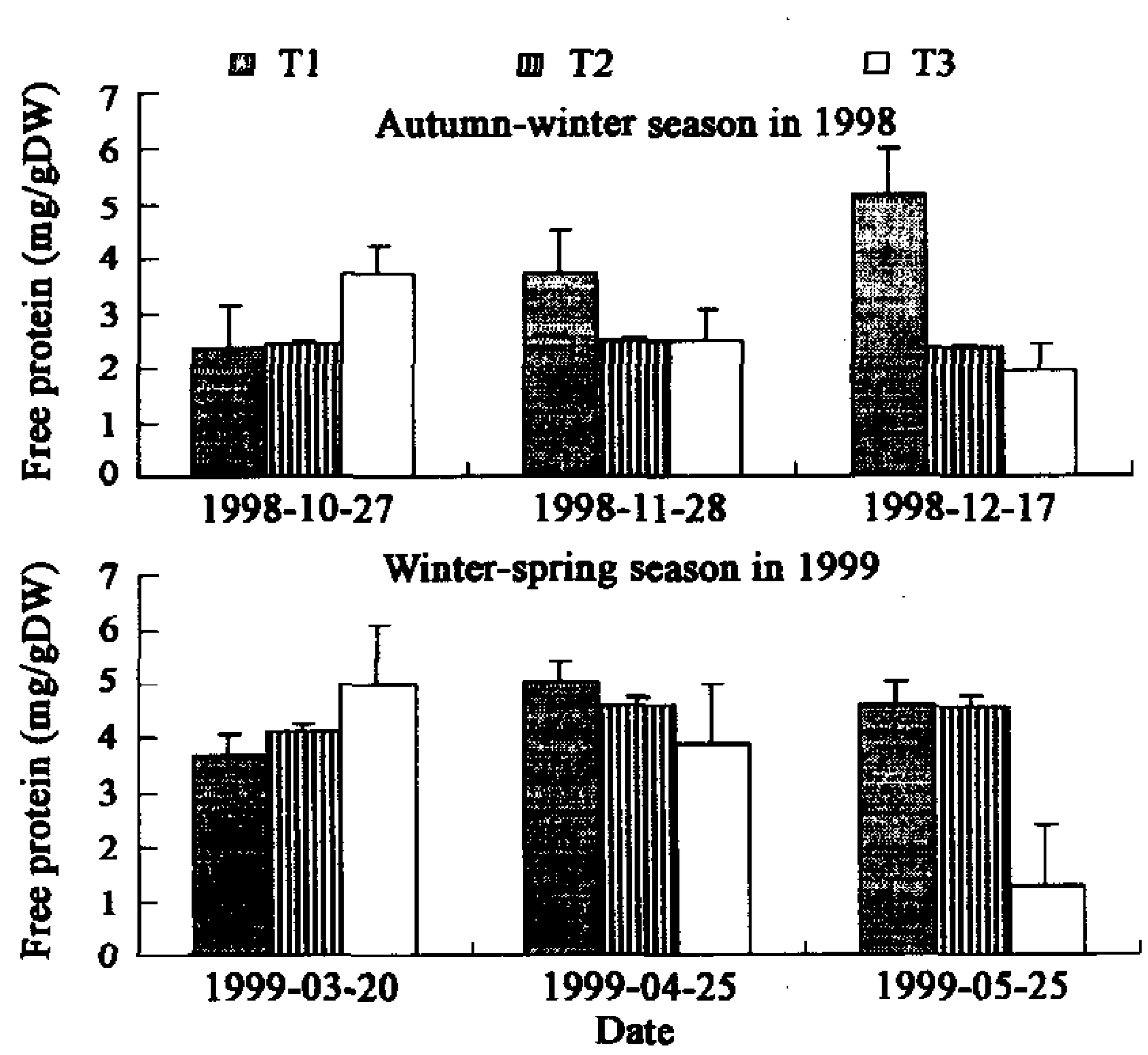

Fig. 2 Effect of different water treatments on free protein content of cucumber leaves under the solar greenhouse during different seasons

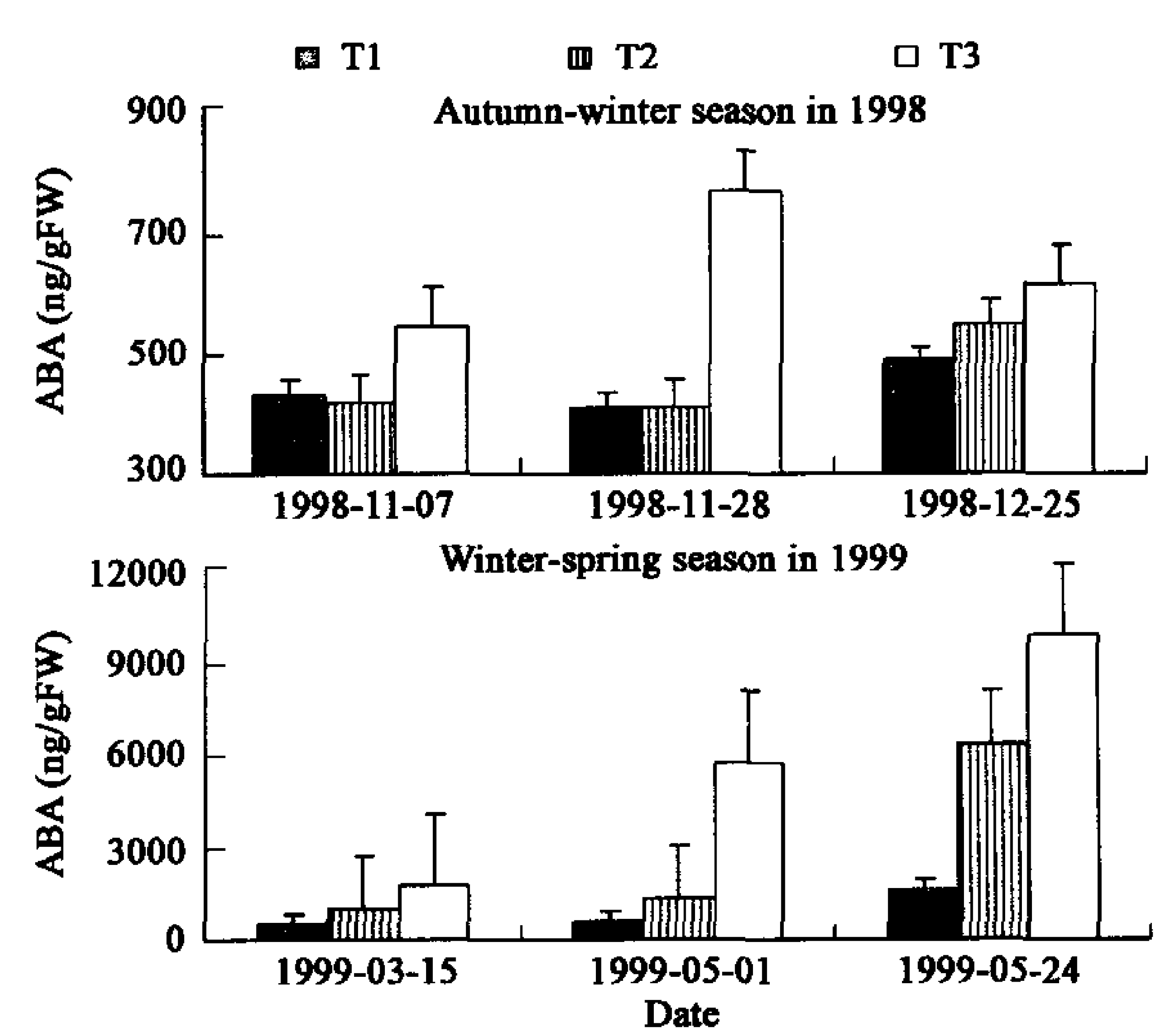

Fig. 3 Effect of different water treatments on ABA content in cucumber leaves in the solar greenhouse during different seasons

3 Discussion

Proline is a compatible solute and has been proposed to stabilize subcellular structures and to scavenge free radicals[12]. In plants, proline catabolism may provide amino nitrogen and reducing power to cells that recover from stress[13,14]. Traditionally, the major function of compatible solutes were osmoregulation[15,16]. Recently, it became evident that the functions of compatible solutes are not likely to be as straight forward as initially believed. Many papers suggested that instead of being directly involved in regulation of cell turgor, their possible role was to adjust metabolic pathways to altered environmental conditions[17~19]. Contrary to previous suggestions, the true role of proline in osmotic stress protection is still to be determined. Our results indicated that the proline and free protein content in T3 were the highest among all the treatments at the beginning of the treatments, whereas when time prolonged, the concentration of proline and free protein in T3 were not the highest, instead, they were the lowest. It is possible that proline and free protein may play a more complex role via regulating numerous metabolic and hormonal pathways rather than directly contributing to osmotic adjustment, which supports Serrano's conclusion[18].

In a longer term, the water loss of plant should be regulated according to the amount of available water in the soil[20,21], which indicated that plants must be able to sense the soil drying and then 'respond' to it by regulating their stomata. Such a mechanism may be termed as a feed-forward mechanism. Liang and Zhang[22] have revealed that such a feed-forward mechanism might indeed work through ABA, a plant growth substance, as a soil drying signal. ABA can be produced in the roots in the drying soil and transported through transpiration stream to the shoots and leaf expansion rate and other physiology will be regulated. From our experiment it was found that when the soil water decreased the cucumber leaf ABA content increased no matter what season it was, it meant that with the less water available, the root send more single to the shoot.

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