ACHIEVEMENTS OF JOINT RESEARCH IN HEAT-TOLERANT VEGETABLE CROPS

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ABSTRACT

Progress has been made in research on heat-tolerant vegetable crops through the joint efforts of the Sino-Japanese scientists[a)] since November 1986. In Shanghai, vegetable breeding materials with heat tolerance have been selected from a total of 231 sweet pepper, cucumber and Chinese cabbage cultivars and new crossings were made. Significant effects on yield increase of sweet pepper and other crops were obtained in the experiments using different cover materials. Various methods for testing the heat tolerance of vegetable crops were studied and success was achieved, particularly in using the chlorophyll-meter to test the heat tolerance of cucumber crops.

Purpose of research

Shanghai is located at latitude North 31°in the northern part of the sub-tropical zone. The mean temperature in a year is 15.7 °C (the mean temperature in July and August is 27.8°C and the maximum temperature is 38.9°C). The supply of vegetables in Shanghai is usually lacking in variety and quantity during the hot season in August and September mainly due to the effect of typhoons. Based on the conclusions reached during the fifth meeting of the Sino-Japanese scientific exchange working group on agricultural sciences and technology, research for the development of stable production techniques for vegetables in the tropics has been carried out through the collaboration between the Shanghai Academy of Agricultural Sciences, Guangdong Academy of Agricultural Sciences, and Tropical Agriculture Research Centre, Japan since 1986. The research aims at breeding vegetables with good heat tolerance and adaptability to tropical conditions, and also at developing techniques of vegetable cultivation in the hot season. The main subjects during the period 1986-1990 were as follows : breeding cultivars (including breeding materials) of pepper, cucumber, and Chinese cabbage with heat tolerance and disease resistance ; studies on the physiology of heat tolerance and disease resistance ; development of cultivation methods to achieve high and stable yield of vegetable crops during the hot season.

Materials and methods

1 Selection of heat-tolerant and disease-resistant cultivars of sweet pepper, cucumber and Chinese cabbage

1) Sweet pepper

Fifteen sweet pepper lines had been tested in field experiments for the effect of different sowing dates (5th January, 5th February and 5th March) and yields were compared in 1987. In 1988, the same experiments with two sowing dates (25th February and 25th March) were carried out. Twenty-five lines were obtained and the heat toler-

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ance of 20 lines was evaluated. The resistance to CMV infection was tested by the inoculation of seedlings at the two-leaf stage and by growing them in plastic tunnels (mean temperature, 27.8°C. maximum temperature 34.7°C).

2) Cucumber

Field experiments to analyse the effect of sowing dates and cultivars were carried out in 1987 using fifteen lines. The three sowing dates were 24th May, 14th June and 4th July. In 1988, the same experiment involving 28 lines and one sowing date (20th May) was conducted. Heat tolerance of 7 lines was studied in plastic tunnels (mean temperature 28.3°C, mean maximum temperature 45°C in 20 days).

3) Chinese cabbage

Eighteen Chinese cabbage cultivars were used in field experiments with different sowing times (5th August and 24th August) and the yield were compared in 1987. The experiment was repeated in 1988 with two sowing dates (28th July and 9th September) and 30 cultivars and lines.

2 Research on cultivation methods for achieving high and stable yield of vegetables in the hot season

1) Cultivation of sweet peppers in plastic tunnels in the summer season

The harvest period of sweet peppers can be prolonged by improving the ecological environment inside the tunnels with plastic sunshading materials. Four treatments (tunnels covered with plastic sheet, white plastic fine net, plastic sheet plus silver plastic fine net and control without cover materials) were implemented in 1987. The experiment was repeated in 1988 with three treatments (plants covered with silver fine net or black fine net directly on top of the tunnels, and covering without touching the leaves with silver fine net).

2) Cultivation using simple and convenient cover meterials

Lettuce and spinach were used in the experiment. White, gray or black plastic fine nets were used to cover the plants with a simple support of bamboo. Plants without cover materials were used as controls.

3 Physiological characteristics of heat-tolerant plants

Relationship between the content of chlorophyll and heat tolerance of cucumber.

The chlorophyll value of 16 cucumber cultivars was tested in the experimental plot by using a chlorophyll-meter (SPAD-501) in 1987. The relationship between the chlorophyll value and content was studied using cucumber cv. Shanghai 103. The chlorophyll values obtained from the front part or base part of the same leaf were compared.

In 1988, cucumber cultivars with either high or low heat tolerance were used in the experiments. The rate of decrease of the chlorophyll content of cucumbers cv. Yanrg Hang, cv. Jin Yan No. 4, cv. Xie Zuo No. 17, cv. Lu Chun No. 32, cv. Natsu Sango, Sagami Hanjiro, Shimoshirazu Jibai, Ochiai Aonaga and Chang Chun Mici was tested by using the chlorophyll-meter (SPAD-501). The method was as follows :

1) The first chlorophyll value obtained with the chlorophyll-meter was taken as the background (or value A).
2) Samples were treated for 60 minutes at 45°C.
3) The treated samples were stored in the dark (25°C) for 48 hours and then tested again with the chlorophyll-meter to obtain the chlorophyll value B. The rate of decrease of chlorophyll $=(A-B)/A\times100\%$.

Results

1 Selection and breeding of heat-tolerant and disease-resistant cultivars of sweet pepper, cucumber and Chinese cabbage.

1) Sweet pepper

(1) Effect of the difference in the sowing dates in the yield of sweet pepper

It was found that the yield of sweet pepper in the first sowing (5th January) was significantly higher than that of sweet pepper (average yield of fifteen sweet pepper cultivars) in the second and third sowings in 1987. However no significant difference was found between the yield of sweet pepper sown on 5th February and 5th March (Table 1). The experiment also showed that the yield of the cultivars in the first sowing was 19.9% higher than that of the plants in the second sowing and 26.8% higher than the yield of plants in the third sowing. In the case of the cv. Shuang Feng the results were different. In 1988, the sowing date was 5th February and 25th March in order to test the heat tolerance and disease resistance of different cultivars in the fields. The plants in the first sowing were harvested from 17th June to 3rd August and the yield was 1.09 kg/m^2. The plants in the second sowing were harvested from 4th July to 1st August and the yield was 0.20 kg/m^2, mainly due to severe infection with virus diseases.

(2) Comparison of yield cultivars

The yield of Ace was the highest among the fifteen cultivars tested in the experiment of 1987. No significant difference was found between Ace and Jia Pei No. 3. Pymidori, Cui Yu No. 2, Sakura Wonder, Wonder Bell (Table 2). It was also found that the yield of cv. Chigusa was the highest among the 25 cultivars tested in the experiment of 1988, followed

Table 1 Variance of mean yield of 15 sweet pepper cultivars sown at different times

Sowing date	Mean yield kg/4.5m^2	Variance	
		SSR 0.05	SSR 0.01
5th January	7.0	a	A
5th February	5.8	b	B
5th March	5.5	b	B

* Mean value of three duplicates for 15 cultivars

Table 2 Variance of mean yields of 15 sweet pepper cultivars

Cultivar	Yield kg/4.5m^2	Variance	
		SSR 0.05	SSR 0.01
Ace	9.2	a	A
Jia Pei No. 3	8.8	a	A B
Kyomidori	8.2	a b	A B C
Cui Yu No. 2	8.0	a b	A B C
Sakata Wonder	7.7	a b c	A B C D
Wonder Bell	7.2	a b c	A B C D
Shuang Feng	6.6	b c d	A B C D
Satsuki	6.1	b c d	B C D E
Jiang Qiao Qie Men	5.6	c d	C D E F
Wu Xi Qie Men	5.6	c d	C D E F G
0036-7-1	5.0	d e	D E F G
Ying Kou Qie Men	5.0	d e	D E F G
Tao Pu Qie Men	3.5	e f	E F G
Ying Jing Qie Men	2.9	f	F G
Takii Wonder	2.3	f	G

* Mean value of three duplicates

by cv. Gu Xiang. The yield of cv. Chigusa, Gu Xiang, Zao Feng. Cui Yu No. 2 and Akino was significantly higher than that of CK cultivar Jing Quao Qie Men.

(3) Virus diseases of sweet pepper cultivars

In 1987, field surveys on virus infection were conducted among sweet pepper cultivars on 12th June and 9th July. On June 12th the incidence of virus infection in Jia Pei No. 3 and Yang Jin Qie Men was lower than 10% and the disease index was below 2(Table 3). However, on July 9 the incidence of virus infection of the cultivars tested was 100%, and the disease index exceeded 30. No significant difference was observed between them.

A survey was also carried out in the field for the detection of virus infection in the plants sown on 1st July and 16th July : cv. Zao Feng was found to have the lowest virus incidence and disease index (45.15%, 10.75). These results showed the existence of a certain relationship between the disease resistance and yield of sweet peppers under high temperature conditions.

(4) Screening for heat tolerance and disease resistance of sweet peppers under high temperature conditions

The yield of sweet pepper varied markedly depending on the level of virus disease resistance under the high temperature conditions of plastic tunnels. The cultivars Bell Homare and CM9-4-2 were found to give the highest yield and exhibit the highest resistance among the 20 cultivars tested. The plot yield of Bell Homare was 73.74% higher than that of the control cultivar, cv. Yang Jin Qie Men. The incidence of virus infection and disease index of cv. Bell Homare 17.6% and 7.49, respectively. The plot yield of cv. CMP-4-2 increased by 59.93% as compared with the control cultivar. The incidence of virus infection in CM9-4-2 was 21.51% and the disease index was 3.83. For the CK cultivar, the incidence of virus infection was 55.85% and the disease index was 16.33. The cv. CCM 036 had a relatively higher resistance against virus diseases. The incidence of virus infection of CCM036 ranged between 14.15-18.84% and the disease index between 3.17-5.01. However the yield was somehow lower. The yield of ROO27, CM2-8-2 was high but the disease resistance was lower.

2) Selection of heat-tolerant and disease-resistant cucumber cultivars

(1) Comparison of cucumber yield from the plants sown at different times

Significant differences (at 1% level) among the yield of the plants sown at different dates were confirmed based on the square-error method in 1987.

Table 3 Incidence virus diseases in 15 sweet pepper cultivars*

Sowing date / disease / Cultivar	5th January		5th February		5th March		Mean	
	Incidence (%)	Index	Incidence (%)	Index	Incidence (%)	Index	Incidence (%)	Index
Jia Pei No. 3	3.3	0.47	3.3	0.47	13.3	2.83	6.6	1.26
Tiang Qiao Qie Ben	22.5	6.35	6.6	2.86	6.6	1.90	11.9	3.70
Yang Jing Qie Men	5.0	6.71	10.0	1.40	4.1	1.80	6.3	3.70
0036-7-1	13.7	3.86	10.3	1.50	32.6	4.70	18.8	3.35
Tao Pu Qie Men	10.0	2.39	9.7	1.36	17.4	7.17	12.3	3.64
Shuang Feng	18.5	7.93	6.6	0.97	23.3	3.33	16.1	4.08
Wu Xi Qie Men	30.0	4.29	13.7	3.03	16.6	3.33	20.1	3.55
Ying Kou Qie Men	13.3	1.90	40.0	10.47	20.0	4.77	24.4	5.71
Wonder Bell	21.8	3.13	26.6	5.70	45.8	9.63	31.4	6.15
Ace	6.6	0.96	27.0	4.80	34.4	6.83	22.7	4.20
Takii Wonder	40.7	11.26	16.6	3.33	10.3	7.60	34.4	7.33
Kyomidori	10.7	1.53	16.6	3.33	10.3	2.43	12.5	2.43
Cui Yu No. 2	3.3	0.46	20.0	3.80	16.6	4.27	13.3	2.84
Satsuki	33.3	4.76	14.0	1.50	45.2	9.30	30.8	5.19
Sakata Wonder	3.0	6.11	43.3	7.13	50.0	9.05	41.1	7.43
Average	17.54	3.73	17.68	3.44	25.55	5.27		

* Disease assessed on 12th June

The mean yield of all the cultivars sown on 24th May was 22.7% higher than the mean yield of the same cultivars sown on 14th June and 55.8% higher than the mean yield of the cultivars sown on 4th July (Table 4).

(2) Comparison of yields of different cucumber cultivars

The experiment of 1987 showed that the yield of cv. Shanghai 103 was the highest among the 16 cultivars tested. However, no significant difference was found between cv. Shanghai 103 and cvs. Zhong Nong No. 11, No. 1101, Xie Zuo No. 17, Lu Chun No. 32, and Jin Yan No. 4. The yield of cvs. Shanghai 103, Zhong Nong No. 1101 and Xie Zuo No. 17 was significantly higher than that of the other 13 cultivars (Table 5). Twenty eight cultivars or hybrids were tested in 1988. The yield of cv. Shanghai 103 was again the highest among them. It was 109.25% higher than the yield of Jin Yan No. 4 (CK). The yield of cvs. Shanghai 104, Xia Feng No. 1, Zhu Cheng Autumn and Rensei x Jin Yan No. 2 was 39.1%, 36.09 %, 33.61% and 27.54% higher than that of Jin Yan No. 4 (CK), respectively.

(3) Diseases of cultivars

Downy mildew and diseases caused by *Phytophthora* spp. were the main diseases of cucumber in 1987. It was found that cvs. Jin Yan No. 2 (CK), Shanghai 103, Zhong Nong No.1101, Lu Chun No. 32 and Xie Zuo No. 17 were slightly more resistant to downy mildew than Jin Yan No. 4. (perecentage below 15% and disease index below 3). Cucumber cvs. Zhong Nong 1101, Shanghai 103, Xie Zuo No. 17, Jin Yan No. 4(CK) and No. 2(CK) showed a relatively higher resistance to diseases caused by *Phytophthora* sowings. Anthracnose was observed on the plants from the second and third sowings.

Table 4 Variance of mean yield of 16 cucumber cultivars sown at different times*

Sowing date	Mean yield kg/4.8m²	Variance	
		SSR 0.05	SSR 0.01
24th May	15.6	a	A
14th June	4.8	b	B
4th July	2.4	c	B

* Maen value of three duplicates for 16 cultivars

Table 5 Variance of mean yields of 15 sweet pepper cultivars

Cultivar	Yield kg/4.8m²	Variance	
		SSR 0.05	SSR 0.01
Shanghai 103	13.8*	a	A
Zhong Nong No. 1101	13.3	a	A B
Xie Zuo No. 17	12.7	a	A B C
Lu Chun No. 32	11.3	a b	A B C D
Jin Yan No. 4 (CK)	10.6	a b c	A B C D E
Tsubasa	7.5	b c d	A B C D E F
Jin Yan No. 2 (CK)	7.3	b c d	B C D E F
Rensei	7.2	b c d	B C D E F
Tokiwa Jibai	6.5	b c d e	C D E F
Asomidori	6.4	c d e	C D E F
0100	6.0	d e	D E F
Koufuyokusei No. 3	5.4	d e	D E F
Nisshi Aonaga Fushinari	4.9	d e	D E F
Shimoshirazu Jibai	4.4	d e	E F
Yamato Sanjaku	3.2	d e	F
0035-1	2.1	e	F

* Mean value of three duplicates

The disease incidence of Zhong Nong 1101, Yamato Sanjaku (35.6% and 37.7%) was lower than that of the others cultivars. The virus disease index of the cvs. Shanghai 103, Xie Zuo No. 17, Zhong Nong No. 1101 and Lu Chun No. 32 was below 15, while the index of Jin Yan No. 4 and No. 2 was 19.75 and 19.95, respectively.

(4) Heat and disease tolerance of cucumber at high temperatures

The yield of cv. Lu Chun No. 32 was the highest among the 7 cultivars tested. It was 46.73% higher than the yield of cv. Jin Yan No. 4 (CK). The yield of cv. SHARP-1 was 34.58% higher than that of the cv. Jin Yan No. 4. The disease incidence and index of cv. Lu Chun No. 32 were 20% and 4 and the incidence and index of cv. Jin Yan No. 4 were 100% and 20.

3) Selection and breeding of Chinese cabbage varieties with heat tolerance and disease resistance

Eighteen Chinese cabbage lines were studied in 1987. The highest mean weight per head was obtained from cv. San Dong No. 6(2.25 kg/head) The mean weight per head of cvs. 83-2, Cheng Za No. 5, Shen Yang Kuai, Qing Hai, Early No. 5 and Zhu Tong Bai was higher than that of Shao Bai Kou. The percentages of bacterial soft rot of cv. San Dong No. 6., Zhu Tong Bai, Chang Cun Kuai Cai, and Shao Bai Kou were below 50% and the disease index below 1.5. Thirty Chinese cabbage lines and cultivars were tested in 1988. Chinese cabbage cvs. White Sun and Juang Long were found to form heads earlier than the others. The highest yield was obtained from cvs. Shao Za No. 65 and Beijing No. 100. Three cultivars, (Bright Moon, Unknown-2 and Tropical Pride) were found to have the lowest rate of infection with bacterial soft rot, downy mildew and viruses among the early maturing cultivars and two cultivars (Shao Za No. 65 and Beijing No. 100) showed the lowest infection rate among the intermediate and late maturing cultivars.

2 Cultivation methods to achieve high and sustainable yield of vegetable crops at high temperature

1) Summer cultivation of sweet pepper in plastic tunnels

Different sunshading materials were used in the experiment to cover the tunnels for producing sweet pepper in the summer of 1987. It was shown that the temperature inside the tunnels decreased and the relative humidity increased by covering the tunnels with fine net and sheet, etc. The effects of sunshading materials were more significant when sunlight was strong. Fine net was the most effective among the three materials used, as the temperature inside the tunnel decreased from 40.5°C (control tunnel without cover materials) to about 37°C and the relative humidity increased from 49% (control tunnel) to 63%. The yield of sweet pepper in summer and autumn was 1.95 kg/m^2, or 1.28 times higher than the yield achieved in the control tunnel. The weight of single fruit was also increased (Table 6).

In 1988, it was shown that the use of a silver fine net was the most effective among

Table 6 Yield of sweet pepper cultivars grown in tunnels in 1987

Period / Yield g/0.1 ha / Treatment	Before treatment	After treatment						Total
		Late July	Early August	Late August	September	October	November	
Tunnel without covering	1714	29	0	51	2	464	309	855
Tunnel without treatment	1907	23	0	0	64	408	456	950
Tunnel covered with sunshading sheet	1752	30	0	0	49	550	819	1448
Tunnel covered with sunshading net	1653	137	67	218	115	542	871	1949

the three materials studied when it covered directly the tunnels. The sunshading rate of the silver fine net was about 68.7%. The maximum temperature was reduced from 40-44°C to 34-37°C when the plants were covered with a silver fine net and the minimum temperature increased from 22-23°C to 23-24°C. The effect varied with the sunshading materials (silver and black fine net) and covering methods, i. e, directly on top of the tunnels or use of a simple and convenient supporting system. The yield of plants covered directly with a silver net was 2.02 kg/m^2. The results obtained in 1987 and 1988 indicated that sweet pepper can be produced in Shanghai in the summer season by using a fine net. The use of a silver fine net was more effective than that of a black fine net in the summer cultivation (Table 7).

2) Simple and convenient cultivation techniques

Lettuce and spinach were used in the experiment to assess the effect of simple and convenient cultivation techniques in 1987. Effects of nets of different colors were compared. The sunshading rates of white, gray and black nets (all supported with small bamboos) were 34.8%, 45.1% and 47.6%, respectively. The temperature under white, gray and black nets which was 3.36±0.63°C, 6.07±2.05°C and 5.21±2.04°C was lower than that without shading (CK). The yield of the crisp type of lettuce was higher under shading with white or gray nets. However the yield of the butter head type of lettuce was higher under shading with gray or black fine nets. White fine net was found to be preferable for spinach. The same results were obtained in the experiment conducted in 1988. The yield of crisp lettuce under white, gray or black file nets was 31.5 kg/m^2, 3.06kg/m^2, 2.64 kg/m^2, while the yield of the control was inly 2.4kg/m^2. The yield of the butter head type lettuce under gray, black and white fine nets was 4.28 kg/m^2, 3.72 kg/m^2 and 3.34 kg/m^2. The increase in yield ranged from 14-31.4% depending on the sunshading materials used.

3 Physiological characteristics of heat-tolerant plants

Relationship between the chlorophyll content and heat tolerance of cucumber.

The chlorophyll content of 16 cucumber cultivars from the second and third sowings was determined by using a chlorophyll-meter (SPAD-501) and the data obtained were compared with the yields. No significant relationship was found between the chlorophyll content and yield when the test was made directly in the field. The chlorophyll value recorded from the front part of leaf was slightly different from the value observed at the base part of the same leaf. A positive correlation was observed between the chlorophyll value and chlorophyll content. Cucumber cultivars differing in their heat tolerance (two spring type cultivars, six summer and autumn type cultivars) were used in the experiment of 1988. The heat tolerance of the cultivars was studied by using the method referred to as rate of decrease of chlorophyll content. The mean rate of decrease of the chlorophyll content of the summer and autumn types of cucumber was 15.95% and the mean rate of decrease of the chlorophyll content of the spring type of cucumbers was 24.8%. This method requires only a small amount of sample and is easy to handle. Further experiments are currently being conducted (Table 8).

Table 7 Effect of sunshading nets on sweet pepper yield

Period / Yield g/0.1 ha / Treatment	Before treatment	After treatment										Total
		Middle July	Late July	Early August	Middle August	Late August	Early September	Middle September	Late September	October	November	
Silver sunshading net	1567.7	461.2	58.2	94.9	76.0	49.9	47.5	49.0	42.7	41.2	25.0	1468.6
Black sunshading net	1671.3	449.4	351.0	64.9	64.9	39.1	28.9	115.0	86.5	26.2		1225.9

Table 8 Rate of decrease of chlorophyll content of 9 cucumber cultivars

Type	Cultivar	Date of test			Mean	
		26th September	8th October	12th October		
Summer cucumber	Natsusango	17.1*	8.4	5.3	10.3	15.9
	Sagami Hanjiro	19.5	13.7	8.4	13.9	
	Shimoshirazu	21.6	14.3	9.5	15.1	
	Xie Zuo No. 7	22.5	17.2	11.6	17.1	
	Jin Yan No. 4	20.3	18.8	13.5	17.5	
	Lu Chun No. 32	22.2	19.2	14.1	18.5	
	Ochiai Aonaga	22.9	19.5	14.8	19.1	
Spring cucumber	Chang Chun Mici	27.7	22.8	18.4	23.0	24.8
	Yang Hang	30.2	30.0	19.2	26.5	

* Mean value of three duplicates.

Conclusion

The three major achievements of the collaborative studies between the Sino-Japanese scientists since the establishment of the project in November, 1986 are as follows :

1 Selection and breeding of heat-tolerant and disease-resistant sweet pepper, cucumber and Chinese cabbage cultivars

A total of 231 sweet pepper, cucumber and Chinese cabbage lines and cultivars have been tested for heat tolerance and disease resistance in the last two years. Promising lines and cultivars with good heat tolerance were identified. Sweet pepper cvs. Chigusa, Gu Xiang, Zao Feng, Cui Yu No. 2, Akino, Ace and Jia Pei No. 3 showed a higher heat tolerance, yield and disease resistance than the other 77 cultivars and lines. Cucumber cvs. Shanghai 103, Zhong Nong No. 110, Xie Zuo No. 17, Lu Chun and Zu Cheng Qiu Gua exhibited the highest heat tolerance, yield and resistance to downy mildew and diseases caused by *Phytophthora* spp. and viruses among the 64 cultivars and lines tested. Among the 83 Chinese cabbage cultivars and lines tested, the Chinese cabbage cvs. White Sun, Juang Long, Unknown-2, Early Mature No. 5 showed an early maturity and adequate heat tolerance, cvs. Shao Za No. 65 and Beijing No. 100 exhibited a high yield and disease resistance.

2 Cultivation methods to achieve high and sustainable yield of vegetable crops in hot season

Microclimate in the tunnels can be improved by covering the tunnels with sunshading nets. The yield of sweet pepper grown in the tunnels can be increased. The use of a silver net was the most effective among the various nets tested. In summer and autumn, the temperature of the soil of lettuce and spinach fields can be reduced by covering the plants with a simple and convenient supporting and shading system. The growth and yield of lettuce and spinach under such conditions can be improved.

3 Physiological characteristics of heat-tolerant plants

The chlorophyll-meter (SPAD-501) has been used to study the relationship between the chlorophyll content and heat tolerance of cucumber. It was found that the method referred to as rate of decrease of the chlorophyll content was superior to other methods and easy to handle. The rate of decrease of the chlorophyll content of the spring type of cucumber was higher than that of the summer and autumn types of cucumber.

Discussion

Nkansah, G. O. (Ghana) : Apart from the chlorophyll-meter used for testing heat tolerance in your cucumber crops what other methods did you use and to what extent were they successful ?

Answer : The other methods include : electrolyte leakage, TTC reduction rate, water loss and leaf temperature. In the case of cucumber, all the methods enabled to differentiate the North China summer varieties and South China spring varieties. In the case of pepper the results were inconsistent and in the case of Chinese cabbage, the electrolyte leakage method and chlorophyll reduction method enabled to differentiate the Taiwanese tropical varieties from the autumn heat-sensitive varieties.