STUDIES ON STRESS TOLERANCE OF VEGETABLES IN CHINA : EFFECTS OF COVER MATERIALS ON GROWTH AND YIELD OF SWEET PEPPER

Takehiko Nakashima*, Kenichi Hida*,
Weipo Zhou**, and Kai Lai**

ABSTRACT

Guangzhou city, located in the southern part of China, experiences temperatures above 30°C and heavy showers from June to September. Farmers usually produce vegetables on bare ground during this season, hence the yield and quality of the products are very low. A few varieties of sweet pepper (*Capsicum annuum*) are cultivated with or without mulches consisting of plastic film or some other materials during the hot season.

In field trials conducted in 1987, the yield of the earlier planting (April 9) was 1/9 of the yield of the later planting (May 18). in the latter, harvest continued from July 28 to October 28, and the yield in August and September was much lower than that of October due to high temperature. The highest yield was obtained by the combination of cheesecloth cover and plastic mulch. The production was 20 times higher than that in the case of bare ground cultivation.

The overall yield in 1988 was slightly lower due to stem rot incidence. Among the cover materials tested on pipe houses, the yield was highest when covering included both cheesecloth and windbreak-net. The yield in the open field was lower regardless of the use of plastic mulch. A hybrid variety from Shanghai showed a higher yield than local varieties of Guangzhou.

Introduction

Guangzhou city, located in the southern part of China and under the tropic of Cancer, experiences temperatures above 30°C from June to September and heavy showers at frequent intervals. Farmers usually produce some vegetables on bare ground during the summer, hence the yield and quality of the products are very low. Presently, people prefer sweet peppers, introduced in recent years to native red peppers. Farmers tried to produce sweet peppers, but they recognized that it was more difficult to grow sweet peppers during the hot season than native red types.

This study was carried out as the first attempt to increase the yield and improve the quality of sweet peppers by using new protected cultivation methods.

Materials and methods

Sweet pepper cultivars included 'Sandaojin', a local tropical type developed in Guangdong province, which was used in 1987 and 1988, and 'Jiapei-No. 3', a hybrid type from Shanghai province, characterized by the production of large fruits which was used in 1988.

* National Research Institute of Vegetables, Ornamental Plants and Tea, Ano, Mie, 514-23 Japan. Dispatched under a tropical agriculture reesearch prgram from TARC.

** Cash Crops Research Institute, Guangdong Academy of Agricultural Sciences, Guangzhou, Guangdong, People's Republic of China.

White cheesecloth (100 mesh, light transmission 70%), polyethylene film (0.1 mm thick) and black windbreak-net (light transmission 40%) were used as cover materials. Rice straw, white polyethylene film (0.01 mm thick) and silver grey polyethylene film (0.02 mm thick) were used as mulch treatments.

In 1987, the effect of cultivation on bare ground and that using various types of plastic mulch or cheesecloth were compared in 'Sandaojin' for two planting dates. The experimental design consisted of three replications. The experiments were conducted on a dry paddy field located in Guangdong Academy of Agricultural Sciences. Sweet pepper was sown on April 9 and May 18, and transplanted on May 14 and June 22, respectively.

In 1988, the experiments were conducted in another paddy field in the same area, and a comparison of the effect of cultivation on bare ground, and that using mulch and cover materials, in 4 pipe houses (each size 6 m width×30 m length) on growth and yield was carried out. Figure 1 shows a diagrammatic representation of the pipe house and cover materials. Two cultivars were sown on March 31, and transplanted on May 15, respectively.

Results and conclusion

1 Experiment in 1987

Table 1 shows the weather conditions in Guangzhou city. Temperatures above 30°C continued from June to September, and showers occurred at frequent intervals. Table 2 illustrates the effects of cover materials and mulch treatments on the growth rate of 'Sandaojin'. The effect of cheesecloth cover was more significant on the growth rate but less pronounced on tick and CMV (cucumber mosaic virus) damage than control and

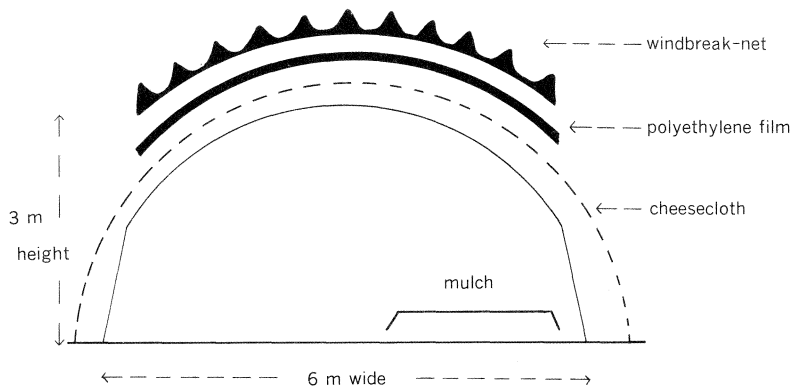

Fig. 1 Diagram of pipe house and cover materials (1988)

Table 1 Weather conditions in Guangzhou city (1987)*

		Month								
		February	March	April	May	June	July	August	September	October
Maximum temperature	°C	—	24.4	25.9	28.9	31.2	32.4	32.8	30.9	—
Average temperature	°C	17.2	20.5	22.0	25.5	27.4	28.5	28.3	26.4	24.9
Minimum temperature	°C	—	17.8	19.2	23.1	24.7	25.8	25.1	24.6	—
Fine days		—	7	14	9	6	13	22	16	—
Sunshine hours		101	42	76	60	138	177	195	127	140
Rainy days		5	11	11	21	12	22	17	12	8
Total rain	mm	23	150	246	368	165	438	224	215	13

*Data from Guangzhou Meteorological Observatory.

Table 2 Effect of cover material and mulch treatments on the growth rate of 'Sandaojin' (1987)

Cover	Mulch	Growth rate				Damage caused by	
		height	leaves	width	harvest	tick	CMV
		cm		cm×cm	date		
None	none	53.6	43.7	29×30	August 4	+++	++
	rice straw	53.1	47.6	28×30	July 28	+++	++
	white	57.4	51.5	31×32	August 4	++	++
	silver	54.3	65.3	33×40	July 28	+	+
Cheesecloth	none	67.1	83.0	42×47	August 4	++	+
	rice straw	68.9	72.5	50×55	August 4	+	+
	white	70.9	66.0	50×52	August 4	+	+
	silver	68.7	75.7	53×55	August 4	+	+

Note : Measured on September 18 (leaves), October 30 (height, width) and July 28 (observation for tick and CMV) (+light ++medium +++severe)
white ; white polyethylene film silver ; silver grey polyethylene film

Table 3 Effect of cover material and mulch treatments on the air and soil temperature (1987)

Covering	Mulch	Air temperature °C		Soil temperature °C	
		air*	maximum*	surface*	10 cm depth*
None	none	32.0 (25.3)	40.5	34.3 (25.2)	30.7 (26.6)
	rice straw	31.5 (25.1)	41.1	34.0 (25.8)	30.2 (26.5)
	white	33.4 (24.9)	42.0	35.0 (25.9)	31.9 (26.7)
	silver	32.6 (25.4)	43.5	37.6 (26.7)	32.3 (27.2)
Cheesecloth	none	33.0 (25.7)	41.0	34.5 (25.6)	31.0 (26.8)
	rice straw	31.7 (25.5)	39.4	35.4 (26.4)	30.3 (26.8)
	white	33.4 (25.3)	42.5	37.5 (26.3)	30.9 (26.5)
	silver	33.9 (25.7)	—	37.4 (26.3)	32.6 (27.1)

Note : Measured on *August 6, **August 19 and ( ) July 29
white ; white polyethylene film silver ; silver gray polyethylene film

mulch treatments. Table 3 shows the air and soil temperature with or without cover materials and mulch treatments. Though the cooling effect of the rice straw mulch was slightly more appreciable than that of other treatments, there was no relationship between the air or soil temperature and the growth rate.

The yield of the earlier planting (April 9) was 1/30 to 1/45 that of the later planting (May 18). In the latter, harvest continued from July 28 to October 28, and the yield in the early stage (July 28 to September 30) was much lower than that of October due to the high temperature. The highest yield was obtained by the combination of cheesecloth cover and plastic mulch. The production was 20 times higher than that in the case of bare ground cultivation (Table 4).

2 Experiment in 1988

Table 5 shows covering methods and the effect of cover materials on light transmission and temperatures. Light transmission did not vary significantly when cover materials were piled up on cheesecloth, than when only cheesecloth was used. Table 6 indicates the effects of cover material and mulch treatments on the growth rate of 'Jiapei-No 3'. Cheesecloth treatments were more effective on the growth rate, but the use of house-B, a combination of cheesecloth and plastic film, which is similar to the rain schelter system in Japan, and is one of the best cultivation methods of vegetables during the hot season (Futatsudera *et al.*, 1976 ; Nishi, 1986) exacerbated the damage caused by stem rot disease compared with other treatments due to the high temperature.

Table 4 Effect of cover material and mulch treatments on yield of 'Sandaojin' (1987)

Mulch	Earlier planting (April 9) cover		Later planting (May 18) cover	
	none	cheesecloth	none	cheesecloth
None	17.3*	29.3	48.3 (44.2)	559.5 (34.5)
Rice straw	22.2	19.7	78.9 (71.9)	1066.2 (75.0)
White	34.8	29.4	155.0 (118.9)	1141.4 (114.2)
Silver	21.5	79.4	150.9 (82.8)	1197.0 (83.3)
Average	23.9	39.4	108.3 (79.5)	991.0 (76.8)

Note : *Total yield, kg/0.1 ha ( ) Yield from July 28 to September 30 kg/0.1 ha
white ; white polyethylene film silver ; silver grey polyethylene film

Table 5 Effect of covering method on environmental conditions (1988)

Test	Cover	Additional-Cover	Light* transmission	Air(Soil)** temperature
			%	℃
Bare ground	none	none	100	34.2 (31.7)
House-A	cheesecloth	none	56.7	37.0 (31.0)
House-B	cheesecloth	polyethylene film	43.3	37.1 (31.4)
House-C	cheesecloth	windbreak-net	41.7	35.0 (28.8)
House-D	cheesecloth	poly film+net	36.5	34.6 (29.0)

Note : Measured on *June 22 and **July 18

Table 6 Effect of cover material and mulch treatments on the growth rate and harvest date of 'Jiapei-No. 3' (1988)

Cover	Mulch	Growth rate height	leaves	width	Harvest date	Damage caused by stem rot
		cm		cm×cm		%
Bare ground	none	52.6	161	42×36	Jun. 25	15
	treated	46.8	155	43×35	Jun. 25	46
House-A	none	82.8	200	69×52	Jun. 25	59
	treated	84.5	337	71×53	Jul. 14	59
House-B	none	90.2	350	73×65	Jun. 25	96
	treated	86.4	502	76×60	Jun. 25	93
House-C	none	93.5	369	64×53	Jun. 25	39
	treated	89.3	550	68×54	Jun. 25	20
House-D	none	97.0	480	69×59	Jun. 25	39
	treated	86.7	375	70×63	Jun. 25	50

Note : Measured on August 20 (leaves), August 28 (height, width) and October 8 (observation for stem rot)

Among the cover materials tested on pipe houses, the yield was the highest when both cheesecloth and windbreak-net were used as shown in Table 7. The yield in the open field was lower regardless of the use of plastic mulch. The yield during the hot season was slightly higher when cover materials were used. A hybrid variety 'Jiapei-No 3' from Shanghai showed a higher yield than the local variety 'Sandaojin' of Guangzhou during the experimental period.

The factors which affect the cultivation of sweet peppers during the hot season have not been fully elucidated and the methods for increasing yield during the hot season and prevention of some diseases require further investigation (Nakashima *et al.*, 1989) .

Since the combination of cheesecloth cover and plastic mulch resulted in the highest

Table 7 Effect of cover material and mulch treatments on yield of sweet pepper (1988)

Variety	Mulch	Bare ground	House-A**	House-B	House-C	House-D
Hybrid	none	174 (74)	784 (206)	642 (235)	1355 (321)	1330 (230)
	treated	232 (37)	1421 (35)	779 (179)	1549 (397)	1698 (360)
Local	none	113 (0)	203 (26)	286 (29)	392 (55)	572 (77)
	treated	110 (2)	387 (98)	318 (60)	462 (33)	442 (76)

Note : * Total yield, kg/0.1 ha ( ) yield from June 25 to August 31
hybrid ; 'Jiapei-No. 3' local ; 'Sandaojin'
** See Table 5.

yield in this region, this method along with a more simplified method is being tested by the extension services in Guangzhou city and by grower cooperatives in this region.

Acknowledgment

We wish to thank Mr. Zhou An Jing, Head of Cash Crops Research Institute, and Mr. Yu Zhi Qiang, Principal Researcher for their suggestions.

References

1) Futatsudera, T., Koike, N., Haga, Y., Wada, A., Iinuma, N. and Simogata, N. (1976) : Studies on the Establishment of a New Cropping System of Summer and Fall Tomatoes in a Cool Summer Region. Bull. Gifu-ken Highland Agric. Exp. Stn. 1 : 1-64. (In Japanese with English Summary).
2) Nakashima, T., Hida, K., Zhou, W., and Lai, K. (1989) : Studies on Physiological Stress Tolerance of Vegetables in China, 2. Effects of Covering Materials on Growth and Yields in Pepper. Jour. Japan Soc. Hort. Sci. 58 (SUPPL. 1) : 312-313. (In Japanese).
3) Nishi, S. (1986) : Protected Horticulture in Japan, Japan FAO Association, Japan Greenhouse Horticulture Association.

Discussion

Ram Phal (India) : In your presentation you outlined the role of cheesecloth and plastic as mulch on the yield of some vegetables. However the title of the presentation refers to stress tolerance. Could you explain which kinds of stresses the use of cheesecloth and mulch enables to alleviate ?

Answer : I believe that the use of cheesecloth and other cover materials enables to alleviate various factors that adversely affect the yield and quality of sweet pepper, namely sunshine, heat, humidity, rainfall, etc. Under strong sunshine, if the air temperature increases to 37°C, the leaf temperature rises to 41 or 42°C.

Saharan, H. A. (Malaysia) : Could you indicate the percentage of increase of yield of sweet pepper grown under cheesecloth cover as compared to that of plants grown without cover ?

Answer : The use of cheesecloth enables to protect the plants from strong sunshine, heat as well as insect and pest damage. Under cheesecloth cover treatment the yield was about 9 times higher than without cover and in the second year about 7 times. However, maximum yield in Guangzhou is about half that of the average yield achieved in Japan.