タバコのオゾン障害の発生におよぼす温度の影響

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Effects of Temperature on Ozone Injury to Tobacco*

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In Setonaikai districts weather fleck in tobacco (Type II and III) usually develops from late in May to the middle of June when plants flower and are topped. It was reported that the incidence of weather fleck was affected by climatic conditions and cultural practices[7]. Above all, amount of rainfall and air temperature during the periods when flecks developed were highly correlated to the incidence of weather fleck, i.e., the greater injury was observed in a rainy year followed by low temperature.

According to our experiments on tobacco[8], an increment in the sensitivity to air-born oxidants was directly related to increased growth temperature, however, a negative correlation between the temperature after exposure and the severity of injury was found when the temperature varied from 10° to 25°C.

The present investigations were made to clarify the effects of temperature on ozone injury to tobacco plants in an environmentally controlled fumigation chamber.

MATERIALS AND METHODS

Three tobacco cultivars (*Nicotiana tabacum* L)[13]; H-2, H-mutant and Bel-W3 were transplanted to 9 cm clay pots and grown in a greenhouse free from natural air pollution. H-2 and Bel W3 with 18～20 leaves and H-mutant at flowering stage were used for tests.

Four experiments were carried out to examine the effects of temperatures before, during and after fumigation upon the responses of plants to ozone. The experimental designs will be written in the later paragraphs.

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Ozone fumigation was conducted for 1.5～2.0 hours at 20～35 pphm levels in full light (23 Klx) in the fumigation chamber which was described previously[18].

Each plot in all experiments consisted of 15 plants and fumigation treatment was repeated three times. Uniform plants were prepared for tests and placed on shallow vats full of water 2 cm in depth under controlled conditions of temperature, light (33 Klx) and relative humidity (65～75%).

Amount of flecks was examined two days after fumigation and the severity of injury was indicated as injury index per plant[18].

EXPERIMENTAL RESULTS

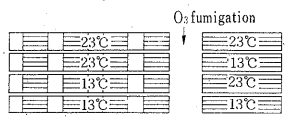
1. Effects of temperatures before and after fumigation on the amount of flecks.

Plants (var. H-2 and Bel-W3) exposed to 10-h light and 14-h dark cycle at 13°C and 23°C for 4 days were fumigated with ozone at 13°C and then they were placed in total darkness at 13°C and 23°C respectively.

Results are shown in fig. 1. The lowest value of injury index was observed in plants subjected to 13°C (before fumigation) —23°C (after fumigation) and the highest value of injury index in plants subjected to 23°C—13°C. Plants subjected to 13°C—13°C were more flecked than those subjected to 23°C—23°C. In both varieties high temperature before fumigation and low temperature after fumigation increased fleck injury.

2. Effects of day- and night-temperature prior to fumigation on the ozone-sensitivity.

It became clear that high temperature before



Injury index	
H-2*	Bel-W3**
0.09	0.38
0.24	3.33
0.00	0.38
0.13	1.73

Note: ▭ 10-h light and 14-h dark.
O_3 dose; *20 pphm×2 h, **20 pphm×1.5 h

Fig. 1 Effects of temperatures before and after fumigation on the amount of flecks

fumigation increased the ozone-sensitivity. Then this experiment was made to examine which temperature, day or night was more effective.

Plants (var. H-mutant) were cultured for 4 days under 12-h light and 12-h dark cycle at four different temperatures; 13°C, 23°C, 13°C/23°C (13°C in the light period and 23°C in the dark period) and 23°C/-13°C. And they were fumigated at 20 pphm ozone level for 2 hours at 13°C. After fumigation they were placed in total darkness at 13°C.

Table 1 shows the results. Plants subjected to 23°C were the most sensitive to ozone and those subjected to 13°C the least sensitive. Plants subjected to 13°C/23°C were more sensitive than those subjected to 23°C/13°C. These results indicate that night-temperature exerts more intensive influence on the ozone-sensitivity than day-temperature.

3. Relation between temperatures during fumigation and the severity of injury.

Plants (vars. H-2 and H-mutant) grown at 23°C were fumigated at 35 pphm ozone level for 2 hours at four different temperatures; 32°C, 27°C, 20°C and 13°C. After fumigation they were placed in total darkness at 13°C.

Results are presented in table 2. Ozone injury was inversely related to temperature. Plants fumigated at 32°C were little injured in both varieties.

Table 1 Effects of day- and night-temperature on the ozone-sensitivity

Temperature		Injury index
Day	Night	
23°C	23°C	4.03
23°C	13°C	1.84
13°C	13°C	0.12
13°C	23°C	3.82

Table 2 Relations between temperature during fumigation and the severity of injury

Temperature	Injury index	
	H-2	H-mutant
32°C	0.00	0.00
27°C	0.45	0.50
20°C	2.50	1.45
13°C	3.30	2.45

4. Effect of temperature after fumigation on the severity of injury and the development of fleck symptom.

Plants (var. Bel-W3) were fumigated at 20 pphm ozone level for 2 hours at 13°C and placed in total darkness at two different temperatures, 23°C and 13°C. And the developmental process of fleck with the progress of time was examined.

Results are shown in table 3. The first appearance of injurious symptoms was observed 4 hours after fumigation in plants subjected to 23°C. When 36 hours or less elasped after fumigation the rate of freshly-flecked leaves (water-soaked stage[12]) to total number of injured leaves was greater in plants subjected to 13°C than that in those subjected to 23°C, i.e., the occurrence and development of injurious symptoms was accelerated by high temperature after fumigation. However, the amount of flecks and the number of leaves flecked were greater in plants sub-

Table 3 Effects of temperature after fumigation upon the severity of injury and the development of fleck symptom

Time after fumigation (hours)		24	36	48	60	72
Injury index	23°C	0.90	0.98	0.99	1.01	1.00
	13〃	2.01	3.00	3.33	3.34	3.33
Number of leaves flecked	23°C	2.8(55)	3.0(25)	3.0(0)	3.0	3.0
	13〃	4.3(94)	5.2(81)	5.8(0)	5.8	5.8

Note: Values in blackets indicate the percentage of freshly-flecked leaves (water-soaked stage).

jected to 13°C than those subjected to 23°C. No more flecking was observed when 48 hours or more elasped after fumigation, even in the plants subjected to 13°C.

Discussion

Some reports[4,5,6,11] indicated that high temperature (23°~30°C) prior to exposure to oxidants increased the susceptibility to them. The same results were also reported on tobacco plants[8,9,10]. Results obtained in this experiment (1) coincided with those mentioned above. An increment in the susceptibility to ozone by high night-temperature might be related to carbohydrate metabolism[2,8].

It was reported that low temperature (10°~18°C) during ozone fumigation increased the amount of flecks[1,3]. Similar results were obtained in this experiment (3), however, no explanation is yet prepared as to the reason for this marked changes in the sensitivity with temperature.

There are few reports concerning with temperature after exposure to oxidants. Hull and Went[4] examined the effects of temperature (3°~36°C) on some vegetables (endive, spinach, etc) and they found a possitive correlation between temperature and the severity of injury. On the contrary, in this experiment (4) greater injury was observed in plants subjected to 13°C than those subjected to 23°C. The same result, a negative correlation between temperature and the severity of oxidant injury, was reported on tobacco.[8]

The authors observed that several plants (*Pharbitis nil, Salvia splendens, Allium fistulosum, Impatiens Balsamina, Fagopyrum sagittatum, Oryza sativa* and *Sesamum indicum*) fumigated with ozone at 13°C were more severely injured than those at 23°C or 33°C. However, such a marked effect of temperature after fumigation, as in tobacco, was not observed except two species, *Oryza sativa* and *Sesamum indicum* (unpublished data). Therefore, the response to temperature after exposure may vary with species as they require different temperature for their metabolic activities.

Severe flecking observed in tobacco fields did not only follow the occurrence of relatively high levels of oxidants but was also accompanied with cool temperature (10°~20°C)[7]. Judging from these facts low temperature after exposure to oxidants would be one of the causal factors for the high incidence of weather fleck in tobacco.

Summary

Investigations were made to clarify the effects of temperature on ozone injury to tobacco in an environmentally controlled fumigation chamber. Results obtained were as follows.

1. Plants grown at 23°C were more sensitive to ozone than those at 13°C. Night-temperature gave a greater effect on the sensitivity than day-temperature.

2. A negative correlation between temperatures during fumigation and the severity of injury was found when the temperature varied from 13°C to 32°C.

3. The occurrence and development of injurious symptoms was accelerated by high temperature after fumigation, however, the amount of flecks and the number of leaves flecked were greater in plants subjected to 13°C than in those subjected to 23°C. No more flecking was observed when 48 hours or more elapsed after fumigation.

4. These results suggested that low temperature, especially after exposure to oxidants, was one of the causal factors for the high incidence of weather fleck in tobacco.

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〔和 文 摘 要〕

タバコのオゾン障害の発生におよぼす温度の響影

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制御環境下のオゾン処理装置を用い，タバコのオゾン障害の発生におよぼす温度の影響について調べた．その結果，

1）23°C 恒温下で生育させたタバコは，13°C 恒温下のものよりオゾン感受性が大であつた．また明期温度よりも暗期温度が感受性に大きく影響した．

2）オゾン処理時の温度を 13°～32°C の間で変えて調べたところ，処理時の温度と障害の発生程度との間に負の相関がみられた．

3）病斑の発生および病斑の進行は高温条件（23°C）で促されたが，障害の発生程度および発生葉数は低温（13°C）条件下にあつたものが大であつた．

4）以上の結果から低温，とくにオキシダント遭遇後の低温がタバコの生理的斑点病の発生と関係が深いことが示唆された．