二氧化硫及氮氧化物對農作物爲害病徵及產量影響

Effect of Sulfur Dioxide and Nitrogen Oxide on Symptoms and Products of Agronomic Crops

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摘 要

分別放置盆栽農作物(水稻、玉米、落花生及番石榴)於作物同化箱內，控制氣溫、相對濕度、風速及二氧化碳濃度，並於自然陽光下(時間爲10: 00至14: 00)使植物進行飽和光合率條件下，利用密閉循環方式，分別燻蒸SO_2，NOx及HF等空氣污染氣體，五天後，作物未呈現症狀。燻氣二週後，葉片呈現各現病徵：如水稻呈現褐色條斑，玉米灰白色條斑，落花生褐斑，番石榴紅褐斑等。較後期病徵則：玉米矮小，水稻葉片枯萎多抽穗少，落花生花器凋萎，番石榴葉片嚴重捲曲等生長及發育遭受破壞，導致產量減少。按氣體影響之大小程度，係依SO_2(0.5 ppm)＋NO_2(0.1 ppm)、SO_2(0.5 ppm)、SO_2(0.1 ppm)＋NO_2(0.1 ppm)＋HF(0.01 ppm)、SO_2(0.1 ppm)＋(NO_2(0.1 ppm)、SO_2(0.1 ppm)及NO_2(0.1 ppm)順序而遞減。同時燻氣SO_2，收穫作物葉片含硫量增加。可能由於SO_2經葉片氣孔進入細胞內，造成生理代謝方面之不平衡，而使植物細胞組織受損，若嚴重時，呈現特別病徵。

關鍵詞：二氧化硫、氮氧化物、農作物、病徵、產量

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1. 通信作者。

ABSTRACT

The potted agronomic crops rice, corn, peanut and guava in assimilation chamber under the saturated photosynthetic condition were fumigated with SO_2, NO_x and HF gases. The fumigating period was from 10:00 to 14:00. After two weeks, the fumigated crops appeared symptoms such as brown mottlings of rice leaf, grey-white mottlings of corn leaf, brown spots of peanut leaf, and red brown mottlings of guava leaf. The more severe damage for the later stage of growth and development were the shorter stem of corn, small tillers of rice, premature fade of peanut flower, and the curved leaf of guava. All of the morphological symptoms resulted in the yield reduction. The damage degree of the fumigating gases were according to the following order to be reduced : SO_2(0.5 ppm) + NO_2(0.1 ppm) , SO_2(0.5 ppm) , SO_2(0.1 ppm) + NO_2(0.1 ppm) + HF(0.01 ppm) , SO_2(0.1 ppm) + NO_2(0.1 ppm) , SO_2(0.1 ppm) and NO_2(0.1 ppm). In addition, the leaf sulfur content of the SO_2-fumigated crops was increased.

Key words : Sulfur dioxide, nitrogen oxide, crops, symptom, product

前　　言

台灣地區燃煤、油之火力發電廠、工廠、汽、機車等排放煙氣均含有高濃度二氧化硫，氮氧化物等污染物，經植物葉面氣孔進入組織細胞內，提高胞液酸度，自由基($\cdot O^-$、 $\cdot OH$、 $\cdot OR$)，氧化物(H_2O_2，HSO_3^-，$^1O_2$)，以破壞細胞膜及大分子之結構，使其失去正常功能，導致農作物生長，發育、品質及產量降低(Elstner 1982; Heath 1980; Landolt and Keller 1985 ; Pauls and Thompson 1984)。故一般研究重點爲此SO_2，NO_x等氣體影響農作物之生化，生理、生長、發育、病症、產量、品質等項目，以及試驗氣體濃度、處理時間、環境、植物種類與受害程度之相關性。經長時間低濃度或短時間高濃度空氣污染物熏蒸植物試驗，所得隱藏性傷害及可見傷害等現象(Treshow and Hnderson 1989; Winner *et al.* 1989)。

孫和蘇(1991)以二氧化硫對一個月大之台農67號水稻進行熏氣：最低發病劑量約爲 0.9 ppm×9小時，4個月已抽穗的水稻，可忍受1.6 ppm×68小時而不發病。在高濃度且高相對濕度下較易形成漂白塊斑，低濃度且低相對濕度下則易呈微銹點斑，一般則常爲兩者之混合型。呂(1991)以800 ppm SO_2 熏蒸六週大之玉米七天：葉片漂白、黃色斑點及壞疽等病徵。

本試驗選定水稻、玉米、落花生及番石榴等四種農作物，放入植物同化箱內控制其氣溫、相對濕度、風速及空氣中CO_2濃度，並於自然陽光環境下，使植物進行飽和光合率，長期性燻氣低濃度SO_2，NOx及HF等空氣污染物，誘發病徵，以研究其影響植物生長及發育之情形。

材料與方法

⑴盆栽作物：把供試作物種子直接播種於裝有混合有機肥料之壤土（壤土：有機肥約20 ：

1）的塑膠盆缽(長×寬×高爲60×17×19cm，水稻及落花生)及直徑25cm之塑膠盆(玉米及番石榴)中，待其發芽出土後，以0.5克尿素作爲追肥，每月施用一次，共計二次。

77年度第一期作爲水稻2月25日，玉米及落花生3月2日。番石2月26日。第二期作爲水稻8月7日，玉米及落花生9月14日。以盆栽台農67號水稻、台南9號落花生，台南16號玉米及泰國種番石榴爲供試品種。栽培期間若發現蟲害時，施用現代靈5,000倍水稀釋液噴霧防治。

⑵燻氣作物試驗：

分別放置盆栽作物於7組作物同化箱(又稱燻氣室，大小爲2.5m及2.0m 高×2m寬×2m長透明塑膠布製成)內，控制氣溫、相對濕度、風速及二氧化碳濃度，並於自然陽光下(時間爲10：00至14：00)使植物進行飽和光合率條件下，利用密閉循環方法，於七天內，每天六小時，分別接受燻氣二氧化硫(0.1及0.5 ppm)，二氧化氮(0.1 ppm)，氟化氫(0.01 ppm)及三者六種的混合氣體另外一箱作爲照組。第六天調查外部形態，若作物葉片有異常現象，立即照相留存。如此連續進行六至八週，視試驗作物之生長期中，對SO_2，NO_2及HF之反應而定。最後收穫作物各部器官，如葉、莖、果實等乾重。不燻氣試驗時，打開作物同化箱門窗，使植物在自然環境中進行生長發育。

鋼瓶內氣體濃度分別爲5% SO_2，1% NO_2，100 ppm HF與空氣混合，氣體由鋼瓶流出，經氣壓調整器(1.0kg/cm^2)流量計而進入作物同化箱；穩定流量(ml/min)分別爲10,30,12及30可達成箱內0.1 ppm SO_2, 0.5 ppm SO_2，0.1 ppm NO_2及10 ppm HF濃度(以壓克力筒出口處氣流爲準)。控制箱內氣流速度爲0.1～0.3 m/sec(利用風速測定儀測定)，每兩分鐘氣流循環一次，氣溫第一次燻氣30～35℃，第二次燻氣28～32℃，相對濕度第一次燻氣35～60%，第二燻氣50～80%，同時外面通入高濃度CO_2，以補助箱內CO_2使其維持250～400 ppm CO_2濃度，以保持植物接近箱外生長環境。利用氣體取樣裝置SO_2及NO_x氣體測定儀每隔60分鐘分別測得各箱內SO_2及NO_x氣體之濃度，以便調整氣體流量計，使通入箱內氣體達到所須要之氣體流量。

⑶葉片含硫量之測定：

把葉片置於烘箱(85℃)供乾48小時，磨碎後再用105℃供乾2小時，待乾冷卻後，倒1.0克樣品入船型容器，上面覆蓋1.0克氧化鋁粉(直徑約0.1㎜)。把此容器置入圓筒型高溫燃燒爐燃燒管內(～1200℃)，且通入氧氣(流量約300 ml/min)，以助樣品燃燒成硫氧化物氣體(約須10分鐘時間)，同時使用sucking pump把氣流導入過氧化氫(3%)溶液，以吸收硫氧化物。

加2～3滴screened indicator入過氧化氫溶液。以sodium borate(0.05N)溶液滴定至neutral steel grey color正。又加入20ml mercuric oxycyanide溶液於另一半之過氧氫溶液，用硫酸(0.025N)滴定至neutral steel gray color爲止。

$S(\%) = (0.0802/m)[V1-V2-0.5(V3-V4)]$

m：樣品之乾重(g)

V_1：Sodium borate (ml) used in the sample determination

V_2 ：Sodium borate (ml) used in the blank determination
V_3 ：Sulphuric acid (ml) used in the sample determination
V_4 ：Sulphuric acid (ml) used in the blank determination

結果與討論

病徵：

燻氣一週後，對水稻、玉米、落花生及番石榴作物並無呈現病徵。按照六種燻氣影響作物病徵分述如下：

⑴燻氣SO_2(0.5 ppm)與SO_2(0.5 ppm)及NO_2(0.1 ppm)混合氣：兩種燻氣對四種作物外部形態均有嚴重影響，第一期作中(a)水稻受兩者燻氣，結果使得中、上位葉之葉片產生黃褐及灰白色條斑(圖1b至圖1g)。最後因病徵嚴重而致使水稻生長受抑制抽穗數少(圖1h)。在第二期中，僅SO_2(0.5)＋NO_2(0.1)混合氣使水稻產生病徵，但病徵和第一期作類似。對(b)玉米則兩種氣體在第一期作及第二期中，均使玉米葉產生嚴重的灰白條斑(圖2b至圖2e)，而使得值株光合作用受阻，植株矮弱(約正常者1/3～1/2高)發育不良(果穗小)(圖2o及圖2p)。對(c)落花生在第一期中，兩種氣體均使其產生灰白、褐色斑點塊及花器受傷害凋萎(圖3c及圖3d)致降低結莢率。但在第二期中，兩者對落花生外部形態均無影響。至於(d)番石榴兩種氣體均使其葉片上產生紅褐斑點，且葉嚴重捲曲(圖4b至圖4d)，以致燻氣第十一週後，兩者使番石榴均不結果。

⑵燻氣SO_2(0.1)＋NO_2(0.1)與SO_2(0.1)＋NO_2(0.1)＋HF(0.01)混合氣：

(a)兩者對水稻外部形態均無影響。(b)兩種氣體在第一、二期作中，前者使玉米葉面產生灰白色斑、褐斑及黃斑，此病徵使得作物葉片受到黃化而枯萎(圖2e至圖2i)，而SO_2(0.1)＋NO_2(0.1)＋HF(0.1)混合氣在第一期作中，發病較前者氣體慢(前者氣體發病須兩週，後者須六週)，在第一期及二期作中，病徵爲黃色斑點及暗紅條斑。雖兩者氣體均使得玉米產生病徵，但以SO_2(0.1)＋NO_2(0.1)對玉米影響較爲重，因其使得玉米得病較早且病葉率較高(表1)。燻蒸七週後，前者促使下位葉病徵由中肋處開始黃化，向兩邊蔓延，後者由葉線向中肋黃化(上葉)。(c)對落花生則以SO_2(0.1)＋NO_2(0.1)＋HF(0.01)影響較大；使葉片皺狀嚴重且產生褐斑(圖3b)。由此可推測HF(0.01 ppm)存於SO_2(0.1)＋NO_2(0.1)混合氣內，促成不同作物發病的嚴重程度及快慢亦有所差別。

⑶燻氣SO_2(0.1)與NO_2(0.1)：

燻氣NO_2(0.1)七週後，玉米葉片呈現紅褐斑及黃斑(圖2j至圖2l)。又燻氣SO_2(0.1)，促使第二期作玉米呈現灰白色斑及黃斑。但兩者單獨氣體均較混合氣體對玉米所造成的病害爲輕(表1)。

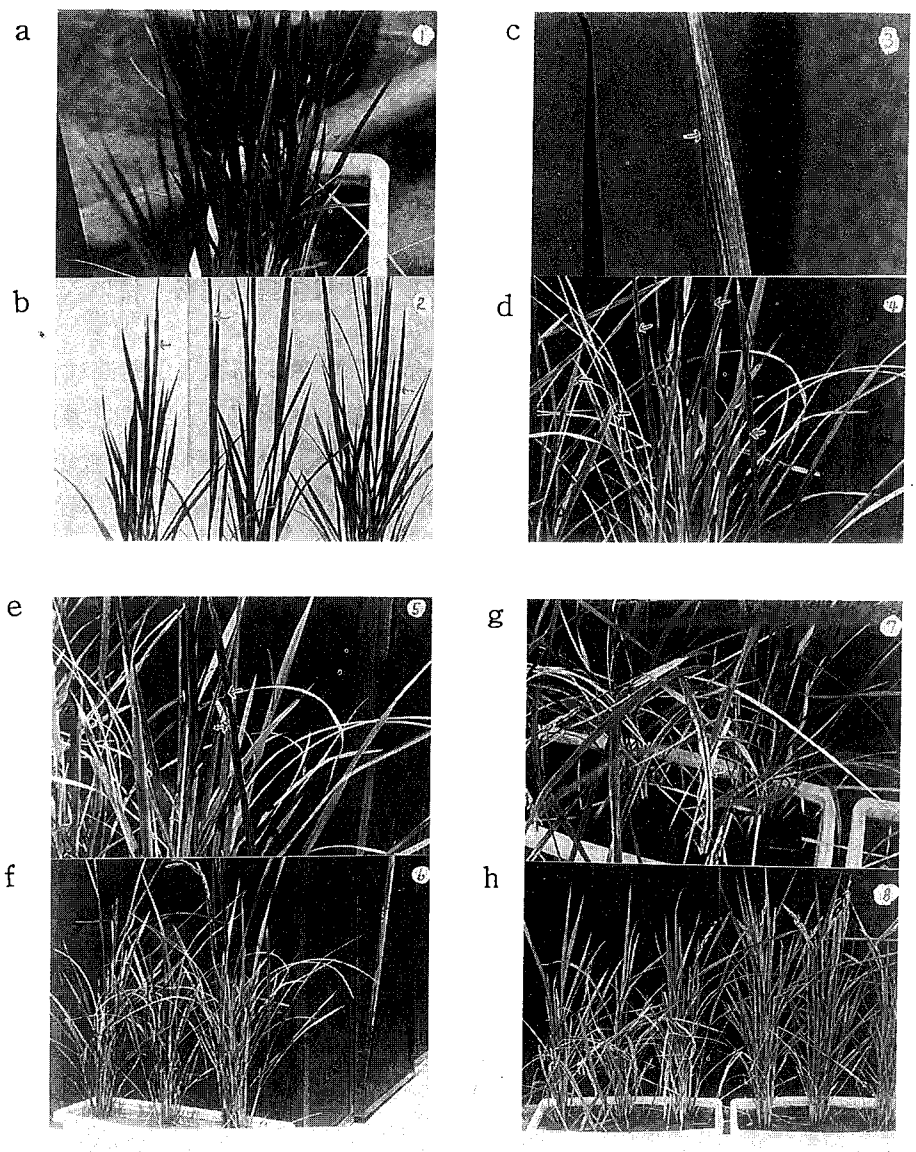


Fig. 1. The morphological symptoms of rice were induced by SO_2-fumigation.

a The control one.

b The yellow-brown mottlings on the upper and middle leaves appeared 3 weeks after fumigating with 0.5 ppm SO_2.

c The yellow-brown mottlings on the leaf tips appeared 3 weeks after fumigating with 0.5 ppm SO_2.

d The brown mottlings over the leaf appeared 5 weeks after fumigating with 0.5 ppm SO_2.

e The brown and white mottlings over the leaf appeared 5 weeks after fumigating with 0.5 ppm SO_2.

f The heading was severly reduced 5 weeks after fumigating with 0.5 ppm SO_2.

g The green vein with white leaf blade appeared 7 weeks after fumigating with 0.5 ppm SO_2.

h A lot of dry leaves and reduced headings appeared 7 weeks after fumigating with 0.5 ppm SO_2.

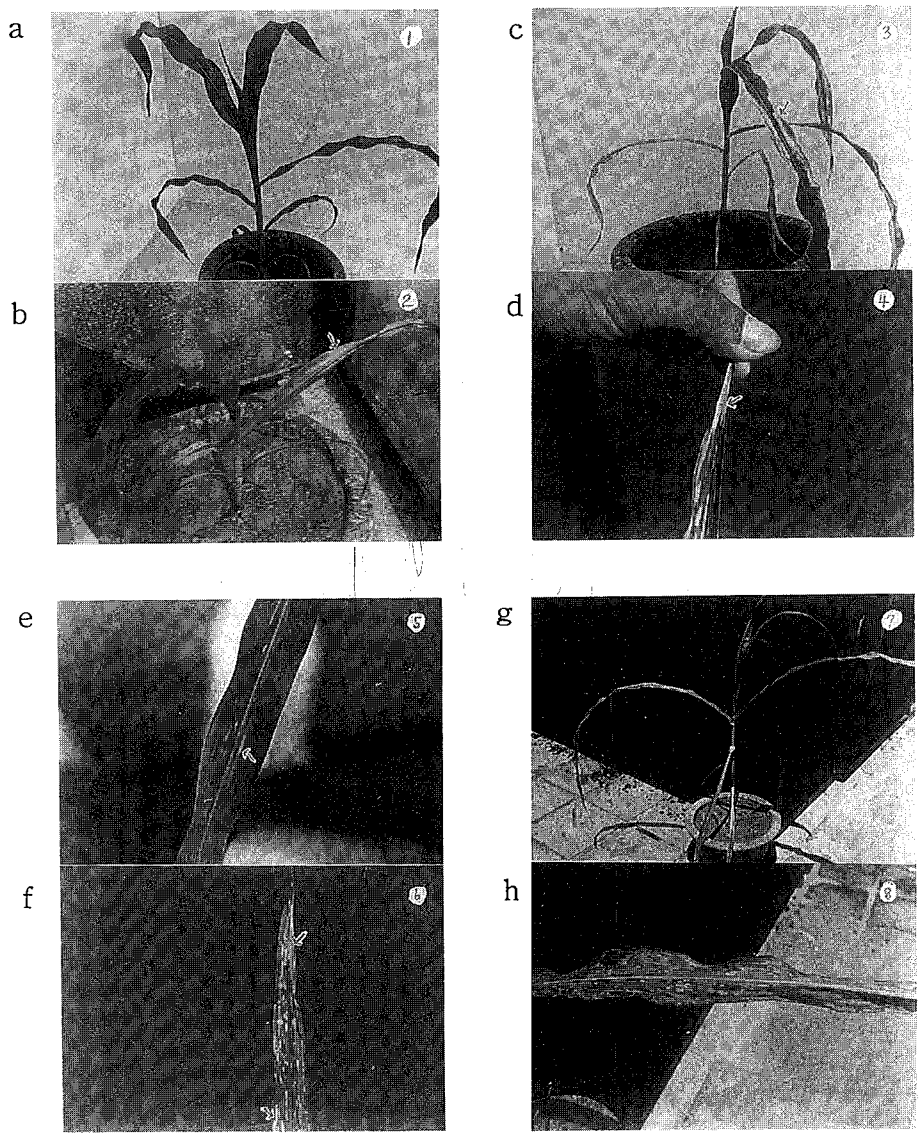


Fig.2. The morphological symptoms of corn were induced by fumigating with air pollutants.

a The control one.

b The grey-white mottlings on the lower leaf appeared 2 weeks after fumigating with 0.5 ppm SO_2.

c The grey-white mottlings over all the leaves appeared 3 weeks after fumigating with 0.5 ppm SO_2.

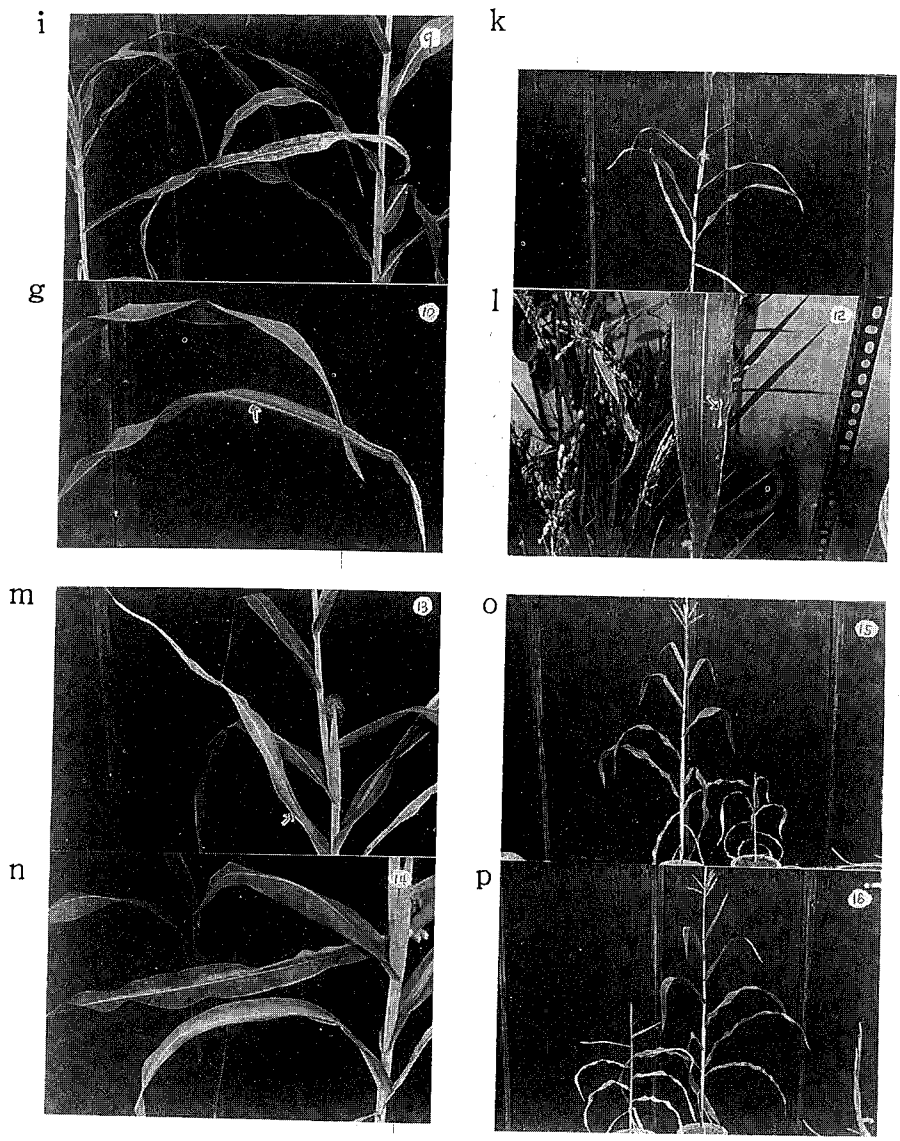
d The grey-white mottlings on the leaf appeared severely.

e The grey-white spots spreaded along the vein direction 3 weeks after fumigating with 0.1 ppm SO_2 and 0.1 ppm NO_2 mixture.

f A lot of grey-white and brown spots spreaded around the middle leaf 5 weeks after fumigating with 0.1 ppm SO_2 and 0.1 ppm NO_2 mixture.

g The grey-white and brown spots spreaded from the middle leaf to the upper one 5 weeks after fumigating with 0.1 ppm SO_2 and 0.1 ppm NO_2 mixture.

h The grey-white and yellow-brown mottings on the leaf appeared severly.



i The plant treated with 0.1 ppm SO_2 and 0.1 ppm NO_2 mixture for 7 weeks vs. the control one.
g The red-brown leaf appeared 7 weeks appeared after fumigating with 0.1 ppm NO_2 .
k The red-brown leaves appeared severely.
l The red-brown leaf margin appeared.
m The yellow leaves appeared 7 weeks after fumigating with 0.1 ppm SO_2, 0.1ppm NO_2 and 0.01 ppm HF mixture.
n The yellowing mottlings spreaded from main vein to the blade margin of lower leaf for 0.1 ppm SO_2 and 0.1 ppm NO_2 and 0.01 ppm HF mixture fumigation, while the yellowing process of the upper leaf was reversed for 0.1 ppm SO_2 and 0.1 ppm NO_2 m ixture.
o There was about 1/3 height corn plant (vs. the control one) with 100% leaf damage 7 weeks after fumigation with 0.5 ppm SO_2 and 0.1 ppm NO_2 mixture.
p There was about 1/2 height corn plant (vs. the control one) 7 weeks after fumigating with 0.5 ppm SO_2.



Fig.3. The morphological symptoms of peanut were induced by fumigating with air pollutants.

a The control one.

b The upper leaf became wrinkled 3 weeks after fumigating with 0.1 ppm SO_2, 0.1 ppm NO_2 and 0.01 ppm HF mixture.

c The brown-spot on the leaf appeared 3 weeks after fumigating with 0.5 ppm SO_2.

d The brown color around grey-white one on the leaf, and the premature faded flowers appears 3 weeks after fumigating with 0.5 ppm SO_2.

e The mixture of grey-white and brown on the leaf tips appeared 5 weeks after fumigating with 0.5 ppm SO_2.

f The symptom became severely 7 weeks after fumigating with 0.5 ppm SO_2.

g There was about 50% leaves showing damaged 7 weeks after fumigating with 0.5 ppm SO_2.

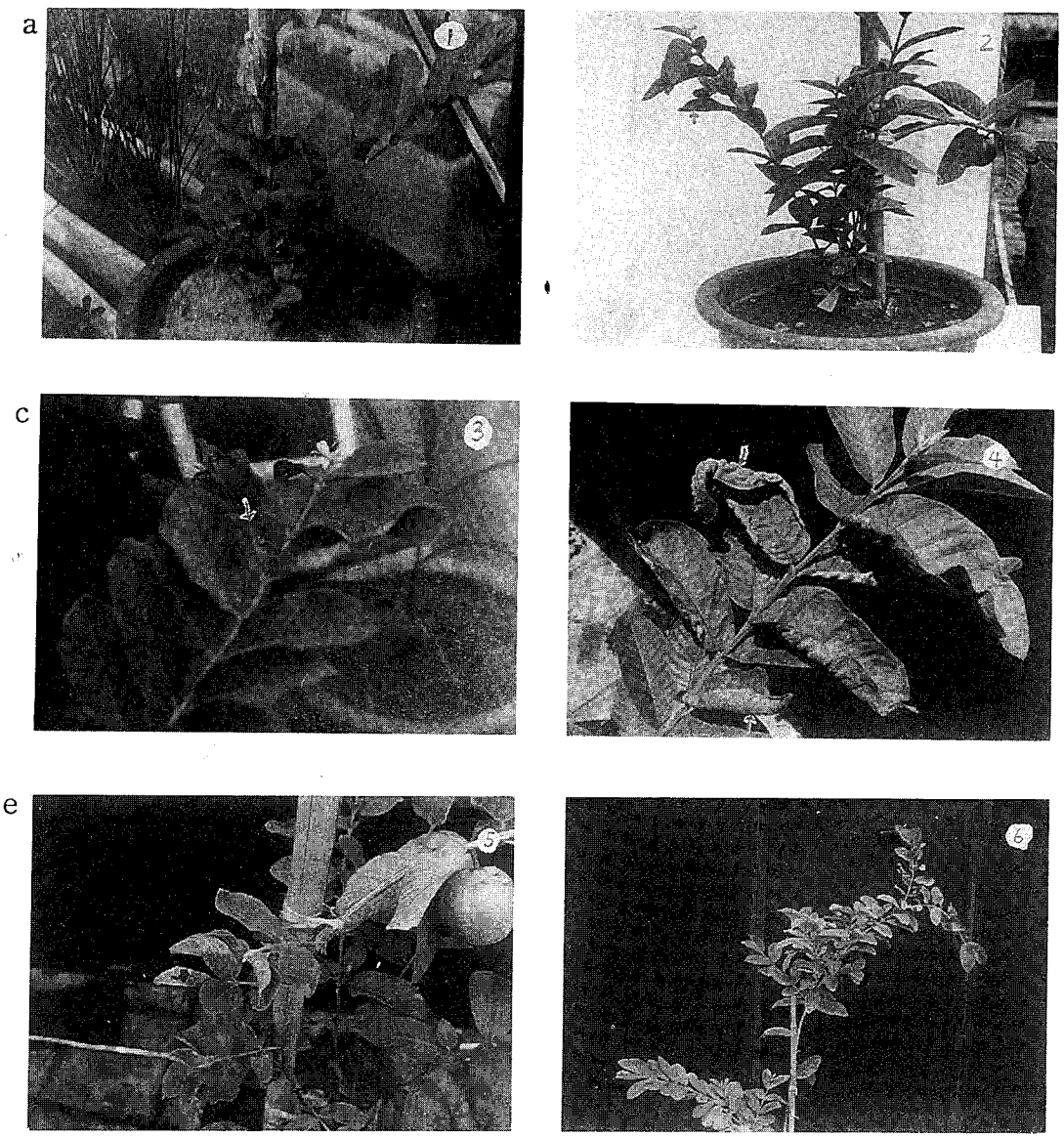


Fig.4. The morphological symptoms of guava were induced by fumigating with 0.5 ppm SO_2.

a The control one.

b The red-brown spots on the middle and upper leaves appeared 2 weeks after fumigating with 0.5 ppm SO_2.

c The red-brown spots on the twisted leaf appeared 3 weeks after fumigating with 0.5 ppm SO_2.

d The symptoms appeared severely 5 weeks after fumigation.

e The red-brown spots on the twisted leaves growing on the branch shoots appeared 7 weeks after fumigation.

f The red-brown spots on twisted leaves growing on the main shoot appeared 14 weeks after fumigation.

Table 1. The injuried plants and leaves induced by fumigating with the air pollutants.

		Rice		Corn		Peanut		Guava	
SO_2	plants(%)	0[@]	0[@@]	0	25	100	0	0	0
(0.1ppm)	leaves(%)	0	0	0	7.89	4.38	0	0	0
SO_2(0.1	plants(%)	0	0	0	100	100	50	25	25
+NO_2(0.1)	leaves(%)	0	0	0	63.16	10.67	16.41	0.66	8.06
+HF(0.01)									
NO_2	plants(%)	0	0	0	75	100	0	50	50
(0.1)	leaves(%)	0	0	0	72.5	5.38	0	2.02	12.3
SO_2(00.1)	plants(%)	0	0	100	100	100	0	50	50
+NO_2(0.1)	leaves(%)	0	0	55.88	83.33	7.79	0	1.91	14.81
SO_2(0.5)	plants(%)	100	100	100	100	100	0	100	100
+NO_2(0.1)	leaves(%)	9.17	75.3	86.21	98.24	11.05	0	13.47	45.83
SO_2	plants(%)	0	0	0	100	100	50	25	25
(0.5)	leaves(%)	0	0	0	63.16	10.67	16.41	0.66	8.06

[@] The first season crops.
[@@] The second season crops.

由以上結果得知：高濃度氣體SO_2(0.5 ppm)對四種作物的爲害，較低濃度SO_2(0.1 ppm)及NO_2(0.1)爲大，可知高濃度氣體對作物的重要性。且高濃度的混合氣體SO_2(0.5)＋NO_2(0.1)較單獨氣體對作物爲害程度較大。低濃度混合氣SO_2(0.1)＋NO_2(0.1)也較單獨氣體NO_2(0.1)及SO_2(0.1)影響較大，可見混合氣對作物的影響較單獨氣體的影響要來得大。

葉片含硫量：

燻氣對作物葉片含硫量及處理組與對照組之比較如表2所示：(a)對照組含硫量(SO_4^{2-},%)均低於處理組者，介於10～100%間，最大差異可達374%，即Ⅰ期作稻處理0.5 ppm SO_2 濃度。(b)若將Ⅰ及Ⅱ期作之平均值經Duncan's MRT 法在5%顯著水準測驗結果：水稻葉片含硫量，處理組SO_2(0.5 ppm)及SO_2(0.5 ppm)+NO_2(0.1 ppm)較大於對照組，二者數值差異顯著。玉米以處理組SO_2(0.1 ppm)+NO_2(0.1 ppm)，SO_2(0.5 ppm)及NO_2(0.5 ppm)+NO_2(0.1 ppm)明顯的大於對照組數值。落花生以SO_2(0.1 ppm)+NO_2(0.1 ppm)及SO_2(0.05 ppm)明顯地大於對照組數值。番石榴以SO_2(0.5ppm)+NO_2 (0.1ppm)大於對照組數值差異頗大。若以燻氣氣體種類及濃度爲準而言，則含有0.5 ppm SO_2 處理組，對提高四種作物葉片含硫量最大且大於對照組，並差異顯著。而添加0.01 ppm HF或0.1 ppm NO_2 處理可提高葉片含硫量，但未達到顯著差異效果。由上述結果知：SO_2 可經作物氣孔進入植物細胞內，且可積存之。

Table 2. The sulfur contents in crop leaves fumigated with the air pollutants.

	Rice			Corn			Peanut			Cuava	
	I	II	ave.	I	II	ave.	I	II	ave.		ave.
SO_2 (0.1ppm)	1.210[@] (201)[@@]	0.754 (119)	0.977^{c}	2.081 (199)	1.593 (121)	1.837^{cd}	1.683 (170)	1.294 (119)	1.488^{cd}	1.473 (104)	1.473^{b}
SO_2(0.1) +NO_2(0.1) +HF(0.01)	1.194 (198)	1.072 (171)	1.132^{bc}	2.039 (195)	2.299 (174)	2.168^{bcd}	1.790 (181)	2.004 (184)	1.896^{bc}	1.611 (114)	1.611^{b}
NO_2 (0.1)	0.529 (88)	0.451 (72)	0.490^{abc}	1.204 (115)	1.471 (112)	1.337^{cd}	1.031 (104)	1.025 (94)	1.027^{d}	1.430 (101)	1.430^{b}
SO_2(0.1) +NO_2(0.1)	1.682 (280)	1.101 (176)	1.391^{abc}	1.884 (188)	2.877 (218)	2.385^{bc}	2.260 (228)	1.969 (181)	2.114^{bc}	2.181 (154)	2.181^{a}
SO_2(0.5) +NO_2(0.1)	2.828 (471)	1.451 (132)	2.148^{a}	3.863 (370)	3.151 (239)	3.507^{a}	3.062 (309)	3.719 (305)	3.190^{a}	3.143 (222)	3.134^{a}
SO_2 (0.5)	2.846 (474)	2.146 (343)	3.486^{ab}	3.416 (372)	2.663 (192)	3.039^{ab}	3.114 (315)	2.155 (198)	2.634^{ab}	2.451 (173)	2.451^{a}
control	0.601 (100)	0.626 (100)	0.613^{c}	1.004 (100)	1.319 (100)	1.161^{d}	0.990 (100)	1.087 (100)	1.038^{d}	1.414 (100)	1.414^{b} (100)

[@] The sulfur content (SO_4^{2-}, %) in the leaves were equal to n=4.

[@@] % check

燻氣降低收穫作物乾重之比較：

盆栽水稻、玉米、落花生及番石榴於作物同化箱外，至抽穗或開花前1～3週，再置入作物同化箱內作連續八週燻試驗，以使作物在生長期(包括營養期，開花期及果實發育期等)決定作物產量較易接受外界因素影響。

六種氣體組合燻氣第Ⅰ及第II期水稻八週後，經移置於作物同化箱外繼續生長至收獲，再利用Duncan's MRT試測氣體對葉重，稈重，穗重及全株重等項目之影響大小比較(表3)：⑴第一期作水稻生長於同化箱內相同於同化箱外者。⑵燻氣影響葉重不顯著差異性。⑶以穗重而言，第Ⅰ期作在SO_2(0.5 ppm)+NO_2(0.1 ppm)燻氣試驗中具有顯著差異。⑷稈重而言，第Ⅰ期作中，則以SO_2(0.1)+NO_2(0.1)+HF(0.01)，SO_2(0.5)+NO_2(0.1)及SO_2(0.5)等三種燻氣組合處理試驗有顯著差異。⑸全株重而言，第Ⅰ期作以SO_2(0.1)+NO_2(0.1)+HF(0.01)，SO_2(0. 5)+NO_2(0.1)及SO_2(0.5)，第II期作以SO_2(0.1)+NO_2(0.1)及SO_2(0.5)+NO_2(0.1)等項目有顯著之差異。基於上述所言，以SO_2(0.5)+NO_2(0.1)，SO_2(0.5),SO_2(0.5),SO_2(0.1)+NO_2(0.1)等燻氣組合試驗數級逐次減少影響水稻器官乾重，故宜以SO_2成份爲主要燻氣之影響因子。其他添加NO_2(0.1)及HF (0.01)燻氣則影響不大。

Table 3. The effect of the air pollutant fumigation on the dry weight of the rice organs.

	Dry wt. (g/plant)							
	leaves		stems		grains		shoots	
	I	II	I	II	I	II	I	II
SO_2 (0.1ppm)	8.766^{a}	5.350^{a}	26.866^{a}	13.783^{ab}	6.366^{ab}	9.383^{b}	42.000^{ab}	28.516^{a}
SO_2(0.1) +NO_2(0.1) +HF(0.01)	7.650^{a}	5.216^{a}	16.766^{a}	10.500^{bc}	5.150^{abc}	7.783b^{c}	29.216^{c}	23.500^{ab}
NO_2 (0.1)	8.866^{a}	4.716^{a}	31.399^{a}	12.000^{abc}	6.616^{a}	13.416^{a}	46.883^{a}	30.133^{a}
SO_2(0.1) +NO_2(0.1)	7.833^{a}	4.433^{a}	19.699^{bc}	9.166^{c}	5.016^{abc}	5.900^{c}	32.549^{bc}	19.533^{c}
SO_2(0.5) +NO_2(0.1)	8.983^{a}	3.816^{a}	15.400^{c}	9.483^{c}	4.183^{c}	6.033^{c}	28.566^{c}	20.166^{c}
SO_2 (0.5)	7.766^{a}	5.260^{a}	15.433^{c}	14.850^{a}	4.716^{bc}	7.550^{bc}	27.916^{c}	27.483^{a}
In assimilation chamber	8.983^{a}	5.233^{a}	25.600^{ab}	12.950^{abc}	6.233^{ab}	7.449^{bc}	40.816^{ab}	25.633^{ab}
Out assimilation chamber	8.266^{a}		25.199^{ab}		6.066^{ab}		39.533^{ab}	

同理利用燻氣水稻方法，比較燻氣對收獲玉米器官乾重影響大小如表4所示：(1)穗重而言，第Ⅰ期作經SO_2(0.1)，SO_2(0.1)+NO_2(0.1)，SO_2(0.5)+NO_2(0.1)及SO_2(0.5)等四種燻氣處理顯著減少。反之，第II期作，對照組有減少之情況，可能由於其他因素，如玉米品系雜交率久一致性，使單株玉米間相異之遺傳性，呈現不同對逆境反應之差異。同樣地，SO_2(0.5)+NO_2(0.1)，SO_2(0.5)等燻氣處理顯著降低玉米四項乾重。

Table 4. The effect of the air pollutant fumigation on the dry weight of the corn organs.

	Dry wt. (g/plant)							
	leaves		stems		grains		shoots	
	I	II	I	II	I	II	I	II
SO_2 (0.1ppm)	6.325^{ab}	7.099^{c}	36.375^{a}	19.650^{a}	13.300^{b}	57.550^{ab}	48.575^{a}	84.300^{ab}
SO_2(0.1) +NO_2(0.1) +HF(0.01)	8.324^{a}	8.825^{bc}	27.100^{a}	12.700^{b}	34.075^{a}	39.525^{bc}	72.250^{a}	61.050^{ab}
NO_2 (0.1)	6.825^{ab}	11.500^{bc}	35.875^{a}	17.399^{ab}	22.674^{ab}	58.950^{a}	65.375^{a}	87.849^{a}
SO_2(0.1) +NO_2(0.1)	6.424^{ab}	13.675^{a}	27.824^{a}	17.950^{ab}	12.225^{b}	26.075^{c}	46.475^{a}	57.700^{cd}
SO_2(0.5) +NO_2(0.1)	2.175^{c}	8.050^{c}	7.925^{b}	11.525^{b}	7.650^{b}	24.575^{c}	17.750^{b}	44.150^{d}
SO_2 (0.5)	3.725^{bc}	11.500^{ab}	9.125^{b}	14.199^{ab}	7.975^{b}	38.850^{bc}	20.824^{b}	64.550^{c}
In assimilation chamber	6.825^{ab}	9.750^{bc}	16.950	23.250^{a}	34.550^{a}	34.650^{c}	58.125^{a}	67.650^{bc}
Out assimilation chamber	7.099^{ab}		26.750^{a}		23.075^{ab}		56.924^{a}	

六種氣體組合燻氣對收獲落花生四種乾重影響大小之比較，如表5所示：(1)第Ⅰ期作，以SO_2(0.5)+NO_2(0.1)及SO_2(0.5)第二種燻氣處理，乾重顯著減少。第II期作，則以SO_2(0.1)+NO_2(0.1)+HF((0.01)，SO_2(0.1)+NO_2(0.1)及SO_2(0.5)+NO_2(0.1)等三種燻氣處理，乾重較顯著減少〔其中NO_2(0.1)氣體成份，值得注意〕。燻氣對番石榴器官乾重影響大小之比較如表6所示：(1)SO_2(0.1)+NO_2(0.1)+HF(0.01)及SO_2(0.5)等二種燻氣處理，果重顯著減少。(2)SO_2(0.1)+NO_2(0.1)+HF(0.01)，SO_2(0.1)+NO_2(0.1)，SO_2(0.5)+NO_2(0.1)及SO_2(0.5)等四種燻氣處理使全株乾重顯著降低。由此可SO_2(0.5)爲主要限制因子，而NO_2(0.1)及HF(0.01)可能也參與。

綜合以上所述，六種燻氣處理四種作物，可降低收穫葉重、莖重、果重及全株重等四項乾重特性，其中以降低果重之經濟價值項目佔多數。又以SO_2(0.5)及SO_2(0.5)+NO_2(0.1)等二項燻氣對水稻及玉米等作物乾重降低率較顯著，而NO_2(0.1)及HF(0.01)與SO_2(0.1)或SO_2(0.5)混合氣，可顯著降低落花生及番石榴器官乾重。

Table 5. The offect of the air pollutant fumigation on the dry weight of the peanut organs.

	Dry wt. (g/plant)							
	leaves		stems		grains		shoots	
	I	II	I	II	I	II	I	II
SO_2 (0.1ppm)	12.366^{ab}	8.933^{ab}	16.133^{bc}	9.733^{abc}	21.966^{a}	14.083^{a}	50.466^{a}	32.750^{ab}
SO_2(0.1) +NO_2(0.1) +HF(0.01)	16.050^{a}	8.283^{ab}	17.300^{ab}	6.766^{cd}	11.916^{bcd}	9.533^{b}	43.100^{a}	24.583^{bc}
NO_2 (0.1)	17.500^{a}	9.100^{ab}	22.200^{a}	10.633^{ab}	13.216^{bc}	16.733^{a}	52.916^{a}	36.466^{a}
SO_2(0.1) +NO_2(0.1)	14.000^{ab}	6.950^{b}	12.949bc	6.383^{cd}	14.033^{bc}	8.983^{b}	40.983^{a}	22.316^{c}
SO_2(0.5) +NO_2(0.1)	10.133^{b}	6.733^{b}	10.966^{c}	5.916^{d}	5.933^{d}	6.633^{b}	27.033^{a}	18.333^{c}
SO_2 (0.5)	9.216^{b}	10.816^{a}	10.066^{c}	12.550^{a}	7.866^{cd}	14.283^{a}	27.150^{b}	35.983^{a}
IN In assimilation chamber	14.600^{ab}	8.900^{ab}	15.816^{bc}	8.833^{bcd}	17.783^{ab}	13.950^{a}	48.200^{a}	33.016^{ab}
Out assimilation chamber	12.750^{ab}		16.783^{b}		16.750^{ab}		46.283^{a}	

Table 6. The effect of the air pollutant fumigaton on the dry weight of the guava organs.

	Dry wt. (g/plant)			
	leaves	stems	fruits	shoots
SO_2 (0.1ppm)	92.425[a]	149.675[a]	664.2[ab]	906.3[ab]
SO_2(0.1) +NO_2(0.1) +HF(0.01)	103.875[a]	139.775[a]	444.0[b]	687.6[b]
NO_2 (0.1)	101.450[a]	167.225[a]	550.6[ab]	819.3[ab]
SO_2(0.1) +NO_2(0.1)	90.875[a]	118.525[a]	481.4[ab]	690.8[b]
SO_2(0.5) +NO_2(0.1)	70.000[a]	143.980[a]	509.3[ab]	643.5[b]
SO_2 (0.5)	90.150[a]	125.200[a]	321.3[b]	536.6[b]
control	92.974[a]	98.525[a]	907.1[a]	1098.6[a]

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