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溫濕度及添加物對百合白絹病之影響

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摘　要

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百合白絹病係由 *Sclerotium rolfsii* Sacc. 所引起，以人工接種風乾菌核於種球周圍土壤 1 公分內，得知 5 粒菌核（接種源密度爲 2.6 個菌核 /100 立方公分土壤）即可使百合出現黃化病徵，且被害度會隨著菌核接種數目的增加而增加。適合本菌菌核發芽之溫度爲 20～28℃，若菌核和植株先經 20℃處理再移置於 28℃下，不但可提高其發芽率且可使百合易於遭受白絹病之爲害。最適本菌菌核發芽和菌絲生長之水分潛勢爲－1～－10 bars，低於－20 bars 時會降低其發芽率和生長速率。當溫度由 20℃提高至 28℃時，無論土壤含水量爲 15 或 30%（W/W），在接種四星期後，百合白絹病被害度均達 0.81，只是在 15% 土壤含水量下病勢進展較快速。各種化合物在土壤中抑制菌核發芽之能力以含氮化合物爲佳，亞硝酸鈉在含氮量 125 ppm 時可完全抑制菌核核發芽，碳酸氫銨在 250 ppm，尿素和碳酸銨在 500 ppm，而醋酸銨和檸檬酸銨需高達 1000 ppm 才可完全抑制其發芽。土壤中添加 1%（W/W）之幾丁質、米糠、蔗渣、牛糞和太空包廢棄堆肥等可抑制菌核發芽，其中以幾丁質效果最佳；且添加 0.5%（W/W）幾丁質最能抑制病害發生，其次是 1%（W/W）米糠和牛糞堆肥。關於無機化合物和有機添加物對本菌和病害之影響，文中有詳盡之討論。

（關鍵字：百合白絹病、接種源密度、溫度、土壤濕度、含氮化合物、有機質）

緒　言

爲因應本省農業新變局，政府極力推行精緻化農業，在各地推廣適地適種之高經濟作物，百合即爲其中之一。目前生產之百合以亞洲型雜交百合（*Lilium asiatic* hybrid），東方型雜交百合（*L. oriental* hybrid）和鐵砲百合雜交品種（*L. longiflorum* hybrid）爲主，提供切花觀賞之用。產區主要分佈於本省中部地區，計有台中后里、水湳、軍功、南投埔里、彰化田中和雲林大埤等，栽培面積約 40 公頃且有逐年增加之趨勢。

Sclerotium rolfsii Sacc.（有性世代 *Athellia rolfsii* (Curzi) Tu and Kimbrough）係一多犯性土媒病原菌（soil-borne pathogen）。據 Aycok (1966)[14] 報告得知約可侵害 100 科 500 種植物，幾乎全世界均有病例發生[50]，而以熱帶地區發生最爲普遍[14]。在台灣則經劉和吳氏[7]整理得知其寄主範圍有 45 科 126 種植物，而後又增加了三種觀賞植物[10]、菱角[5]和百合[8]

共計 131 種。

白絹病爲害百合時，造成種球腐敗和地上部黃化萎凋而死亡[8]。很多報告指出高溫多濕利於本病發生[18,35,45]，至於溫濕度如何影響病害之發生則少有研究；另外本菌腐生能力非常强，在土壤中可佔據未腐熟之有機質[12]，菌絲快速生長並形成大量菌核[18]，如盲目施用有機質，無非提供本菌有利的繁殖環境，致使病害更形嚴重，但是一些含氮化合物可有效抑制菌核發芽和存活[2]，進而降低病害之發生[39]。故本文除探討溫濕度對病害發生之影響外，更就無機鹽類化合物和有機添加物對白絹病菌和病害之影響提出討論，以期做爲防治方法之參考。

病害發生情形

1989 年 5 月至 7 月在台中后里、軍功、水滴和南投埔里，同年 10 月至翌年 1 月於軍功和彰化田中等百合栽培區均發現白絹病之發生[9]。本病爲害百合時，菌絲可侵入種球鱗片和莖基部，致使植株下位葉黃化，並逐漸往上位葉發展，嚴重時整株萎凋死亡，且以莖基部爲中心之土表可見白色絹狀菌絲呈放射狀生長，上面產生黃褐至黑褐色菌核，或剝開土壤時，在地下部種球周圍可見白色菌絲束纏繞[8]，並破壞種球鱗片而呈腐敗狀。病害在栽培田中的分布情形不一，大部分爲局部偶發狀況，當病徵開始出現後，如不加以控制，則病勢很快地呈放射狀往外蔓延，形成萬綠叢中一簇黃的景觀。

白絹病菌菌核埋在土壤深度 2.5 公分以下，即可降低其發芽率，而在土深 7 公分時幾乎不發芽[40]。一般百合種植深度爲種球頂部覆土 8～10 公分，但猶可發現種球被本菌菌絲纏化爲害，是否意味著初次感染源並非經由菌核發芽而感染，而是腐生在有機殘體上之菌絲直接侵害所致，則有待試驗加以證實。

接種源密度與病害發生之關係

土壤中菌核存在的密度與病害嚴重程度有直接的關係。Backman 等（1981）[15]利用土盤技術（soil-tray technique）偵測 500 克土壤中菌核數目與甜菜白絹病發生率呈明顯正相關，相關係數高達 0.83 以上。在溫室中，1 公斤土壤內含有 1000 個菌核的接種源密度，可造成約 75% 的大豆幼苗遭受侵害[12]。然而 Punja（1986）[38]在溫室條件下，測試接種源密度在每 100 立方公分土壤中含 2.5 個菌核時，蘿蔔根可 100% 被侵害。兩者之間的差異在於後者所用之單位土壤，以蘿蔔主根周圍土壤爲主（土表距根 3 公分、5 公分土深距根 1 公分內之土壤）。筆者依據 Pauja（1986）[38] 所提有效感染之土壤體積（competence volume of soil）加以改變，而決定接種源密度換算公式如下：

接種源密度＝100 N/V

$V = 4\pi/3\ [(c/2\pi + 1)^3 - (c/2\pi)^3] \times n$

N＝接種菌核之數目

n＝百合種球數目

c＝種球周徑

V＝有效感染之土壤體積[38]

栽植二顆周徑約 14 公分之百合種球，並在距種球周圍 1 公分內之土壤接種菌核，結果白絹病被害度隨著接種菌核數目之增加而增加（表一）。5 粒菌核（接種源密度爲 2.6 個菌核 /100 cm^3）接種於百合種球周圍土壤，在第 12 天時即可使百合出現黃化病徵，且隨著時間的增加，被害度亦逐漸提高，直至整株死亡爲止。接種 10 粒菌核時，被害度於第 18 天達到一半。被害度一般皆隨著菌核接種數目之增加而提高，且會提前發病[9]。

溫度對菌核發芽和病害之影響

白絹病菌（*S. rolfsii*）菌核發芽方式有爆發式（eruptive germination）和菌絲式（hyphal germination）兩種[41]。菌核在培養基和田土上的爆發式發芽最適溫度爲 21～30℃，低於或超過此溫度範圍時，發芽率明顯降低[40]。筆者以土壤平板測試菌核爆發式發芽率，得知 16 至 32℃間皆可發芽，其中 20～28℃的發芽率最高，介於 80.95～84.18% 之間，而菌核經由 20 和 28℃交互處理，並未能提高其發芽率（表二）。菌核先於乾土表上 3 天後，再加水潤濕，除了 16 和 20℃處理外，其餘溫度處理下菌核發芽率均有明顯降低現象。但 20℃乾土中先靜置三天後再加水置放一天移至 28℃下則發芽率高達 93.65%（表二）[9]。

表一、接種源密度與百合白絹病被害度之關係

Table 1. The relationship between inoculum density of *Sclerotium rolfsii* in soil and the disease severity of lily southern blight

Sclerotial number	Inoculum density[1] (selerotia/100 cm^3)	Disease severity[2]		
		12[3]	15	18
0	0.0	0.00	0.00	0.00
5	2.6	0.13	0.25	0.31
10	5.3	0.25	0.44	0.50
20	10.6	0.44	0.63	0.69
40	21.2	0.56	0.63	0.81

1) Inoculum density represented number of inoculating sclerotia in competence volume of soil around the 14 cm circum size of lily bulb within 1 cm.
2) Disease was divided into 5 grades, 0 = No yellow, 1 = 1/4 part of plant turns yellow, 2 = 1/2 part of plant turns yellow, 3 = 3/4 part of plant turns yellow, 4 = plant wilts and dies. Disease severity = Σ (scale × number of diseased plant at relative scale) / (4 × total number of plants)
3) Days after inoculation.

表二、溫度對白絹病菌菌核發芽之影響

Table 2. Effect of temperature on germination of sclerotia of *Sclerotium rolfsii*.

Temperature[1]	Germination (%)	
	Wet	Dry→Wet[2]
16	53.97	84.13
20	84.13	84.13
24	84.13	71.43
28	80.95	63.49
32	65.08	41.27
20→28	84.13	93.65
28→20	84.13	58.73

1) The soil plate that contained 20 g dry soil and 21 sclerotia was added with 4 ml distilled water and incubated under different temperature conditions. 20→28 represented the soil plate with sclerotia was transferred to 28 ℃ after 1 day of incubation under 20 ℃, while 28→20, the reverse.
2) Dry→Wet represented soil plate was maintained under dry condition for 3 days, then 4 ml distilled water were added.

將菌核乾燥再濕潤時可促進營養泌出[19,41,47]，Punja 和 Grogan[41]將菌核放在 $CaCl_2$ 乾燥箱中 20 小時後，用水沖洗五小時使菌核乾重量減少 25%，而滲漏出胺基酸和碳水化合物之量最多，這些營養物質可增進土壤微生物活力，而抑制其發芽或殺滅菌核[47]。因此種植前若能將田土翻耕並經高溫暴曬，使土壤乾燥後再加以灌溉，則可降低初級感染源之數量。

白絹病菌在土壤溫度 20～40℃下都可危害水稻，造成苗立枯，而最適病勢進展的溫度爲 25～35℃，其中以 30℃下被害度最嚴重[49]。百合白絹病的發生受溫度的變化影響極大，最適發病溫度爲 28～32℃，如將百合先置於 20℃下一星期再移入 28℃生長箱時，可增加被害度（表三）[9]。百合植株生長的溫度需求以 20℃左右爲佳，但本病在 28℃左右易於發生，其原因可能除了溫度利於病原菌的生長外，植株處於較高溫下而呈弱勢生長，使病原菌有機可乘應屬主因。有關此方面的問題值得進一步探討。

表三、溫度對百合白絹病發生之影響

Table 3. Effect of temperature on the occurrence of lily southern blight

Temperature[1)]	Disease severity[2)]	
	2 wks	3 wks
16	0.00	0.00 c[3)]
20	0.00	0.00 c
24	0.00	0.00 c
28	0.25	0.33 b
32	0.25	0.50 ab
20→28	0.44	0.71 a
28→20	0.00	0.00 c

1) Lily plants were cultured in the growth chamber under different temperatures. 20→28 represented lily plants were transferred into 28℃ condition after 1 week of incubation under 20℃, while 28→20, the reverse.

2) The rating of disease severity is the same as in Table 1.

3) Values followed by the same letter in each column are not significantly different at $\rho = 0.05$ according to Duncan's multiple range test.

濕度對菌核發芽、菌絲生長和病害之影響

水分潛勢對菌核發芽有所影響，在－1～－10 bars之間，菌核爆發式發芽率分別爲 97.9%和 91.7%，而低於－20 bars時菌核不發芽（表四）[9]。在不同水分潛勢下，菌絲生長情形大致與菌核發芽情形相似，－1～－10 bars 菌絲生長良好，生長速率在 29.3 mm/day 以上，然而低於－20 bars時，菌絲生長速率明顯降低，尤其在－50 bars下菌絲塊於第五天以後才見菌絲緩慢生長（表四）[9]。

土壤濕度與菌核發芽的相關研究很多[11,33,40]。在 25%～75%土壤含水量下菌核發芽率均在 68%以上，但超過 75%含水量時發芽率隨即降低[11]；以水分潛勢Ψ_S而言，最適發芽者爲－2.5～－10 bars之間，低於－10 bars時菌核發芽受阻[40]，與筆者測定水分潛勢對菌核發芽和菌絲生長的結果相符。

土壤濕度與白絹病發生之關係少有研究。百合種植在 30%土壤水分含量之情況下比在 15%時較利於白絹病之發生，接種三星期後之被害度分別爲 0.63和 0.38。土壤水分含量在 15和 30%之間交替變化時亦會促進被害度，其中土壤含水量先維持 30%一星期後再慢慢降至 15%時被害度爲 0.75最高（表五）[9]。此結果說明了田間白絹病總是發生在灌溉後或下雨後，土壤漸乾時。Boyle（1961）[18]指出土壤保持濕度之情況下，對 *S. rolfsii* 之發育有利，並可增加病害之嚴重性。土壤含水量在 20%（W/W）時，本菌腐生能力最高，並隨含水量之增加降低[6]。在 50～75%下由本菌引起

的小麥莖和根腐病比飽和含水量嚴重[44]，而含水量及土壤質地與病害發生之關係密不可分，在排水性良好的砂質土壤[49]和坋質土含量高、保水性佳的土壤，利於本菌營腐生生長[6]，且可增加病害之發生[46]。

溫濕度交感效應對病害之影響

百合生長在20℃環境下，土壤含水量維持15%時，其被害度較30%高，然而在28℃下，則以30%土壤含水量者較高。生長溫度由

表四、不同水分潛勢對白絹病菌菌核發芽和菌絲生長之影響

Table 4. Effect of different solute water potential on sclerotial germination and mycelial growth of *Sclerotium rolfsii* on corn meal agar.

− Bar[1)]	Sclerotial germination[2)]	Mycelial growth (mm)[3)]					
	(%)	1	2	3	4	5	6
1	97.9	15.5	52.8	79.8			
5	91.7	15.8	53.5	79.0			
10	91.7	16.0	49.8	74.5			
20	79.2	12.5	36.0	55.0	79.5		
30	45.8	0.0	18.3	29.5	45.0	58.5	75.5
50	0.0	0.0	0.0	0.0	0.0	9.5	11.8

1) The solute potential was adjusted to values between -1 to -50 bars by adding appropriate amounts of KC1 into corn meal agar.
2) Each value represents the mean of five replicates, sclerotial germination was rated after 72 hrs of incubation at 28℃.
3) An 8 mm diameter of mycelial disk (from the 7-day-old colony on PDA) was placed onto the center of medium and the mycelial growth was measured each day after inoculation.

表五、土壤濕度對百合白絹病發生之影響

Table 5. Effect of soil moisture on the occurrence of lily southern blight

Soil moisture[1)]	Disease severity[2)]	
(%)	2 wks	3 wks
15	0.13	0.38 b[3)]
30	0.44	0.63 a
15→30	0.25	0.50 ab
30→15	0.50	0.75 a

1) Soil was adjusted to 15 and 30% MHC by adding appropriate amount of distilled water (determined by calculation after drying soil sample at 105℃ for 12 hrs) and kept moisture with plastic bag. 15→30 represented the soil was maintained at 15% MHC for 7 days and then added with appropriate water to adjust soil moisture to 30% MHC. 30→15 represented soil at 30% MHC was progressively dried by natural way down to 15% MHC.
2) The rating of disease severity is the same as in Table 1.
3) Values follow by the same letter in each column are not significantly different at $\rho = 0.05$ according to Duncan's multiple range.

20℃提高至28℃時，無論土壤含水量爲30或15%，四星期後被害度均達0.81，惟在15%土壤含水量下病勢發展較爲快速。由上述結果可知溫度變化，利於病害發生（表六）[9]。

綜合溫度和土壤濕度交感作用對病害的影響，可清楚地發現土壤濕度的效應不比溫度效應强。也就是說，高溫（28℃）下的被害度比低溫（20℃）下高，無關土壤濕度，且在溫度變化下，土壤濕度只扮演著控制病勢進展速度快慢的角色而已。

無機鹽類化合物對菌核發芽和病害之影響

無機鹽類化合物可直接抑制土壤病原菌之生長[42,48]，尤其是含氮化合物可降低白絹病菌菌核之發芽率[2,13,39]。方和劉1988[2]指出土壤含有10 mM之尿素、氰氮化鈣、硫酸銨、硝酸銨、氯化銨或亞硝酸鹽類時，能顯著抑制本菌菌核發芽，其中尿素、氰氮化鈣和亞硝酸鹽類更可殺死菌核。筆者測試二十一種含氮、磷、鉀、鈣和碳之化合物對土壤中菌核發芽和菌絲生長的影響，結果顯示1%（W/W）量之銨態氮化合物如醋酸銨、碳酸氫銨、碳酸銨、檸檬酸銨、鉬酸銨和硫酸銨等，除硫酸銨外都能完全抑制土壤中菌核發芽，其中前四種化合物尙能完全抑制菌絲生長（表七）；另外，尿素和亞硝酸鈉亦能有效抑制菌核發芽和菌絲生長，但硝酸鈣則否。五種含鈣之化合物以1%（W/W）量加入土壤時，除硫酸鈣能促進菌核發芽外，其餘均可抑制菌核發芽，但效果不若銨態氮化合物。磷酸氫鈉和磷酸氫二鈉二種含磷化合物對菌核發芽之抑制能力以後者較佳。含鉀化合物如氯化鉀和硫酸鉀則以前者效果爲佳。關於含碳化合物以丁二酸（琥珀酸）最能抑制菌核發芽，但對菌絲生長則影響不大（表七）。由上述結果可知各種化合物在土壤中抑制菌核發芽之能力以含氮化合物較佳，故進一步測定含氮量與菌核發芽之關係。亞硝酸鈉在含氮量125 ppm時可完全抑制菌核發芽，碳酸氫銨在250 ppm，尿素和碳酸銨在500 ppm，而醋酸銨和檸檬酸銨需高達1000 ppm才可完全抑制發芽，其他如硝酸銨、硫酸銨、鉬酸銨和明礬雖在1000 ppm含氮量時亦不能完全抑制其發芽（表八）。

表六、在不同溫度下土壤濕度對百合白絹病發生之影響

Table 6. Effect of soil moisture on the occurrence of lily southern blight under different temperature condition

Tamperature[1] (℃)	soil moisture[2] (% MHC)	Disease severity[3]		
		2 wks	3 wks	4 wks
20	15	0.06	0.19	0.31
	30	0.00	0.00	0.13
20→28	15	0.69	0.81	0.81
	30	0.44	0.63	0.81
28	15	0.31	0.38	0.44
	30	0.50	0.56	0.69

1) Lily plants were cultured in the growth chamber under different temperatures. 20→28 represented lily plants were transferred into 28℃ condition after 1 week of incubation under 20℃.

2) Soil was adjusted to 15 and 30% MHC by adding appropriate amount of distilled water (determined by calculation after drying soil sample at 105℃ for 12 hrs) and kept moisture with plastic bag.

3) The rating of disease severity is the same as in Table 1.

不同的含氮化合物在相同的含氮量下爲何對菌核發芽之抑制能力不一？Punja和Grogan（1982）[42]指出在高pH值（約8.6）時銨鹽、碳酸鹽和碳酸氫鹽可殺滅菌核，然而在低pH值（約6.0）時則否，因在高pH值下分別可產生NH_3、CO_3^{2-}和HCO_3^-。另自然土中添加各種氮化合物後，僅氨可提高土壤pH值至9.9外，其他處理均在7.7～8.7之間，但所有處理對本菌生長均有抑制作用，土壤經殺菌後，除氨外對本菌生長則無明顯抑制作用[22]。此現象告知二項事實：1.氨在高pH值下可直接抑制本菌生長，2.氮化合物抑制本菌之能力與土壤中的生物因子有關。但是影響菌核發芽能力的到底是土壤pH值、氨氣或是土壤中的生物因子呢？Punja和Grogan（1982）[42]指出本菌菌核在pH 7以上之不同緩衝液水瓊

表七、不同化合物對白絹病菌菌核發芽和菌絲生長之影響

Table 7. Effects of various chemicals on the germination of sclerotia of *Sclerotium rolfsii*

Chemicals[1]	Sclerotial[2] germination (%)	Mycelial growth (mm)[3]	
		3 days	5 days
Alumium sulfate	18	16.8	T
Ammonium acetate	0	0	0
Ammonium bicarbonate	0	0	0
Ammonium carbonate	0	0	0
Ammonium citrate	0	0	0
Ammonium molybdate	0	13.8	T
Ammonium sulfate	30	29.5	P/A
Calcium carbonate	27	20.5	38.8
Calcium chloride	28	19.5	40.5
Calcium nitrate	23	12.5	47.3
Calcium sulfate	80	24.5	39.5
Calcium superphosphate	30	14.5	T
Citrate	27	14.8	T
Glycerin	17	25.0	P/T
Potassium chloride	2	14.5	42.7
Potassium sulfate	74	20.0	39.2
Sodium nitrite	0	0	0
Sodium phosphate, monobasic	57	22.0	41.0
Sodium phosphate, dibasic	19	21.7	42.0
Succinate	0	26.5	43.5
Urea	0	0	0
Check	63	35.8	60.0

1) 1% (w/w) chemical was added into soil with 20% water content.

2) All values are means of four replicates, with 15 sclerotia per replicate.

3) All values are means of four replicates, plate per replicate contains one wheat seed that has been cultured with pathogen for two months. T = *Trichoderma* spp. P = *Penicillium* spp. A = *Aspergillus* spp.

表八、不同含氮化合物對白絹病菌菌核發芽之影響

Table 8. Effect of nitrogenous compounds on the germination of sclerotia of *Sclerotium rolfsii*

Nitrogenous compound	Germination of sclerotia (%)[1]			
	125[2]	250	500	1000
Alumium ammonium sulfate	75.0	76.7	66.7	50.0
Ammonium acetate	91.7	8.3	4.2	0
Ammonium bicarbonate	87.5	0	0	0
Ammonium carbonate	33.3	29.2	0	0
Ammonium citrate	79.2	45.8	8.3	0
Ammonium molybdate	79.2	58.3	54.2	33.3
Ammonium nitrate	62.5	61.7	58.3	54.2
Ammonium sulfate	83.3	66.7	66.7	37.5
Sodium nitrite	0	0	0	0
Urea	41.7	20.8	0	0
Check	75.0			

1) All values are means of four replicates, with 15 sclerotia per replicate.

2) The nitrogen concentration in soil (ppm N).

脂上，其發芽能力完全被抑制，然在 pH 高達 9.7 時菌核仍存活著。方和劉（1989）[3]也以 pH 10 之碳酸鹽緩衝液水瓊脂測菌核活力，結果乃有 56% 之存活率，因而認爲土壤 pH 值並非是使菌核失去活力之主要因子。既然土壤 pH 值與菌核活力無直接關係，那麼土壤微生物所扮演的角色爲何？將菌核培養在含有尿素、亞硝酸鹽或銨態氮化合物之土壤中，經過一段時間後，可由菌核上分離出大量微生物[4,23]，而認爲氮化合物可當土壤微生物之氮素源，以增强其對菌核之定值[23]。相同的，自然土中加入 100 ppm 氮量的硝酸銨可降低菌核發芽率[13]，此可能爲硝酸銨改變土壤微生物相而對本菌發生拮抗作用[30]。方和劉（1988）[2]指出尿素在殺菌土中對菌核發芽及存活全無影響，但加入 *Trichoderma harzianum* 或 *Fusarium ventricosum* 孢子懸浮液或只加少量尿素酶即能使菌核失去活力；然而 *T. harzianum* 和 *F. ventricosum* 單獨存在殺菌土中，對菌核之發芽及存活無作用。又將菌核培養於殺菌土或水瓊脂培養基上，再曝露於含尿素之自然土中，則菌核可被揮發出的氣體氨所殺滅[3]，直接證明土壤微生物與菌核活力無直接關係，氨才是毒殺本菌的主要因子。雖然土壤 pH 值與土壤微生物對菌核存活無直接效應，但卻直接影響氮化合物在土壤中之分解作用而產生氨氣。硫酸銨添加在酸性土壤中產生氨量比在鹼性土壤中少[3]，對菌核的發芽抑制能力亦較弱[3,20,42]，銨態氮化合物在 pH 8.6～9.5 間才能將菌核殺死[42]。另外當土壤添加尿素後，受到微生物分泌的尿素酶所分解而揮發出氨氣以影響菌核發芽及存活[2]。含氮化合物加入土壤後，除了產生氨氣以外，碳酸鹽和碳酸氫鹽類亦可產生 CO_3^{2-} 和 HCO_3^- 而直接殺死菌核[42]。由於各種含氮化合物對於提昇土壤 pH 值之效力不一[4]，影響了氨氣量之產生[3]，以致不同氮化合物在相同含氮量時，抑制菌核發芽之能力不一。

含氮化合物既然可直接影響菌核活力，因此常被用來防治白絹病的發生。例如氮化合物加入土壤後可減輕落花生及甜菜[23]、尿素防治綠豆[1]和硫酸銨及碳酸氫銨減輕草皮[43]等白絹病之發生。其機制不外乎產生氨氣[22,42]和改變土壤微生物相[23]而達防治之效果。若氮肥能與耕作制度或添加拮抗菌相互配合時防治病害效果更佳。Punja 等（1986）[39]添加含鈣或氮量 112 公斤 / 公頃的硝酸鈣或尿素及含氮量 84 公

斤 / 公頃的碳酸氫銨於蘿蔔田後做深耕處理可有效降低白絹病發生。而硝酸銨鈣和*Trichoderma harzianum*一起加入田土時亦能有效防治花生白絹病[28]。

有機質對菌核發芽和病害之影響

有機物質添加對白絹病菌菌核和病害之影響的相關研究並不多見，但實際上卻極度影響病害發生。土壤中有大量未分解的植物殘體或有機質存在時，極有利於本菌的發育[18]，但燕麥及玉米殘體的水抽出物經殺菌之後可抑制本菌之生長[32]。筆者測試苦茶渣、泥炭苔、木屑、幾可質（蟹殼粉）、米糠、蔗渣、牛糞堆肥和香菇太空包廢棄堆肥等八種有機質對本菌菌核發芽之影響，得知以1%（W/W）量各有機質與土壤混合並加水處理7天後，幾丁質、米糠、蔗渣、牛糞和太空包廢棄堆肥等可抑制菌核發芽，其中以幾丁質處理者效果最明顯；相反的，添加1%（W/W）量之苦茶渣可促進菌核發芽（表九）。另外以不同量之苦茶渣、泥炭苔、木屑和幾丁質處理土壤時，顯示除苦茶渣外其餘處理之菌核發芽率隨著添加量之增加而降低，菌核存活率亦然，其中亦以幾丁質添加可有效降低菌核發芽和存活率（表十）。

Johnson（1953）[25]指出在土壤中添加紫花苜蓿後，可促進細菌的繁殖，增加菌核死亡。土壤添加4%苜蓿粉時，可使本菌菌核在1.5～2個月內全部毀滅，2%時2個月，1～0.4%時約3個月，而未添加者在3個月後僅25%遭受破壞。除了土壤添加有機質後會促進土壤微生物之增量，使本菌菌核遭受破壞而死亡[21,25]外，一些好氣性細菌在分解有機質之過程中，會產生乙烯（ethylene）使菌核不能發芽[16]，然而苜蓿粉在分解過程中會產生乙醛（acetaldehyde）和其他揮發性氣體，促進菌核發芽[36]，而利於微生物分解。Linderman和Gilbert（1969）[27]亦發現植物殘體在分解時會產生促進本菌菌核發芽之揮發性物質如甲醇（methanol）、乙醛、異丁醛（isobutyraldehyde）等。可知有機質添加對菌核有正面的促進發芽和負面的摧毀二項影響。衆所周知幾丁質可誘生大量的細菌和放射線菌[37]，分泌抗生物質以毒害病原菌[31]，然而在白絹病菌方面未曾有人報告其可抑制菌核發芽和存活，筆者測試結果認爲其在防治本菌引起的病害方面潛力雄厚，值得進一步探討。

土壤中有大量未分解的有機質時，所有植物均被本菌殺死，然而大量菌核存在時，即使

表九、有機質添加對白絹病菌菌核發芽之影響

Table 9. Effect of organic amendments on the germination of sclerotia of *Sclerotium rolfsii*

Organic matter[1)]	Germiantion of sclerotia (%)[2)]
Oil tea dreg	85.7
Check	76.2
Peat moss	71.4
Sawdust	71.4
Bagasse	64.6
Compost I	59.1
Compost II	57.2
Chaff	47.9
Chitin	0

1) Soil was amended with 1% (w/w) organic matter and then put 15 sclerotia on it after 7 days of incubation. Compost I was the high rotted cattle manure. Compost II was the half rotted waste of sawdust used for mushroom plastic bag culture.

2) All values are means of four replicates, with 15 sclerotia per replicate.

表十、不同量的有機質添加對白絹病菌菌核發芽和存活之影響

Table 10. Effects of various amount of organic amendment on the germination and viability of *Sclerotium rolfsii*

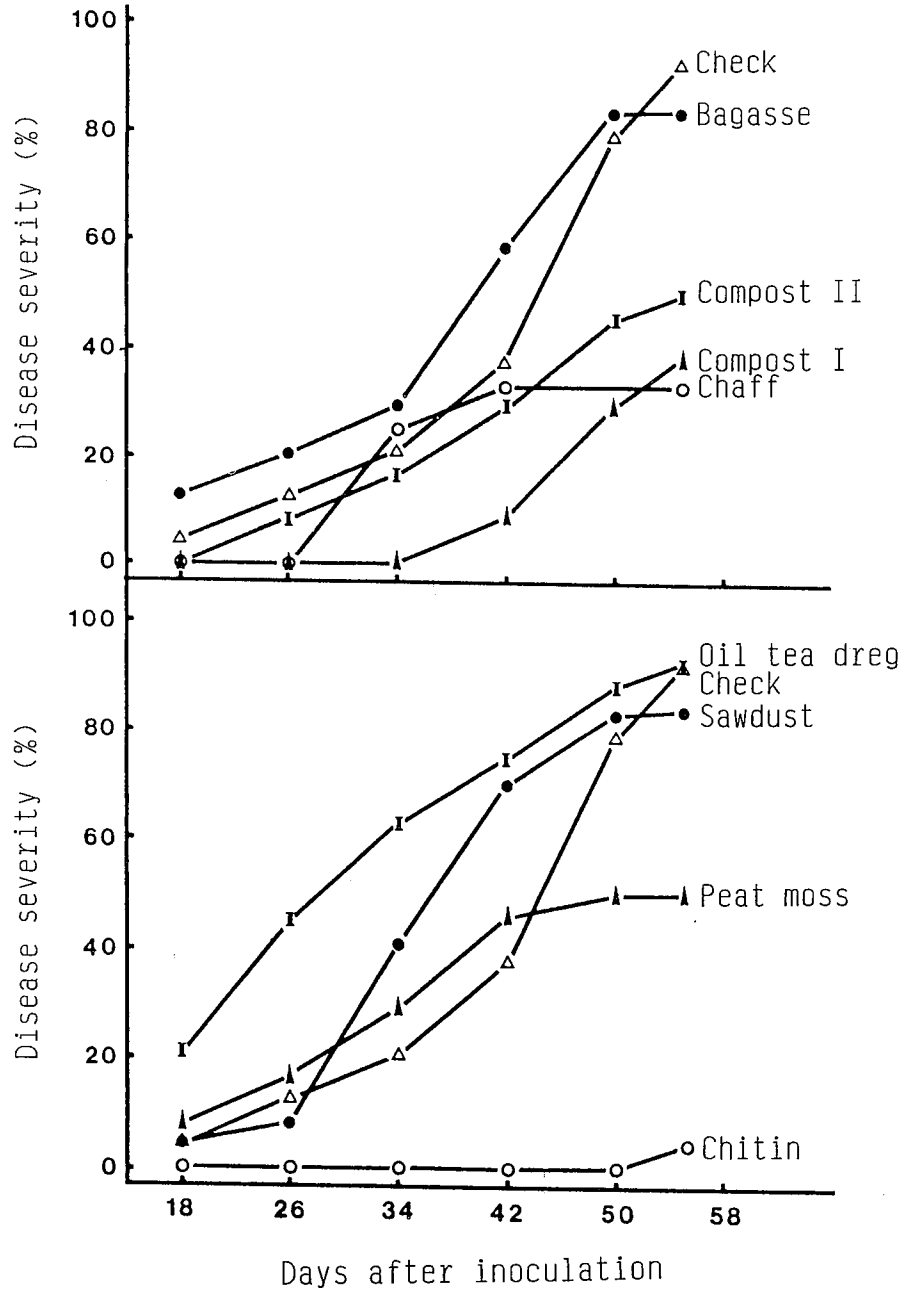
Organic matter	Sclerotial germination/viability (%)[1]			
	0.5[2]	1	2	4
Oil tea dreg	85.7/41.0	85.7/60.0	99.0/40.0	100.0/40.0
Peat moss	87.3/26.7	69.8/30.0	50.8/33.3	39.7/20.0
Sawdust	—	84.1/30.0	54.0/23.3	22.2/ 8.2
Chitin	46.7/45.0	33.3/ 8.0	9.5/ 0.0	0.0/ 0.0
Check	60.3/23.0			

1) All values were means of five replicates, with 21 sclerotia per replicate. Sclerotial germination and viability were examined at 3 and 10 days after organic matter was amended, respectively.
2) Amount of organic matter (gram/100 gram of soil)

是感病植物亦未必被侵襲[24]，無寄主植物之情況下，本菌可在多種植物殘體上繁殖[34]。若除去土壤表層之有機質則可減輕本菌之爲害[17]，因此 Boyle（1961）[18]認爲本菌之菌核並未攜帶足夠的能量以產生代謝物質來殺死寄主細胞使其進入寄生生活，指出了腐生基質對本菌生長及致病能力之重要性。但是亦有報告指出添加堆肥[29]，燕麥桿[21]和苜蓿粉[26,27]可減低病害的發生，其原因可能是釋放氨氣和增加土壤中拮抗微生物的族群數量。筆者以盆栽方式測試八種有機質添加對病害之影響，顯示 1%（W/W）量苦茶渣、木屑、泥炭苔和蔗渣等在發病初期（接種第 34 天以前）病勢進展速度比對照組快，然而在發病後期（接種 55 天以後）則除了苦茶渣處理者外，其餘三者的植株被害度有減緩現象。在八種有機質添加物中，以幾丁質最能抑制病害的發生，其次是米糠和牛糞堆肥，其被害度均在 50% 以下，而對照組則高達 91.7%（圖一）。土壤中添加稻殼和木屑並不能降低太陽花的白絹病發病率，然而添加燕麥桿和蓖麻餅則可明顯降低病害的發生[21]，原因有二：1. 有機質在土壤中分解並釋放出水溶性（添加燕麥桿時）和醚溶性（添加蓖麻餅時）毒害物質，以抑制本菌的生長，2. 促進土壤中的微生物以拮抗本菌[21]。Linderman 氏[26,27]指出紫花苜蓿減輕白絹病菌爲害的作用有下列原因：1. 增加土壤中拮抗微生物之活力，2. 使本菌由抵抗性之菌核變成易受拮抗微生物侵襲之菌絲，3. 消耗菌核能源，使其抵抗力降低而使拮抗菌及腐生菌易於生長在菌核上，4. 阻止新菌核產生，以減少接種源潛勢。關於幾丁質降低病害的作用機制除增加土壤中細菌和放射線菌的量外，是否有抑制物質產生則有待進一步研究。

結　論

瞭解白絹病菌在土壤中的生態有助於防治工作的進行，利用菌核乾燥後再濕潤時會滲漏出胺基酸和糖類的特性，在種植前可將土壤翻耘曝曬後再加水灌溉，以降低接種源數量；或利用菌核於深土中不能發芽之特性，以深耕方式將土表之土壤及有機質深埋入土；另外可添加能提高土壤 pH 值之含氮化合物如碳酸銨、碳酸氫銨和尿素等及降低病害發生的有機質如幾丁質、米糠和牛糞堆肥以直接殺死菌核和間接促進土壤微生物而達到綜合防治之目的。關於防治百合白絹病病害發生最重要的一點是不要有違常規栽培，因爲植物生長勢衰弱時無法抗拒病原菌的侵害。綜合上述氮化合物和有機質對白絹病菌之影響可歸納下列幾點，以作爲本文之總結：1. 提高土壤 pH 值至 9.8 以上可直接對白絹病菌發生毒害，2. 氮化合物加入土壤中釋放出的氨氣會殺死本菌，3. 提高拮抗微生物之活力而抑制本菌的生長，4. 促進菌核之



圖一、有機質添加對百合白絹病病勢進展之影響

Fig 1. Effect of organic amendments on disease development of lily southern blight. Compost I = the high rotted cattle manure, Compost II = the half rotted waste of sawdust used for mushroom. All organic matters were amended at 1% (w/w) to soil, except chitin which was amended at 0.5% (w/w).

形成而進入休眠，5.促進菌核發芽以及土壤微生物之活力，使具抵抗力之菌核變成易受侵害之菌絲。

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ABSTRACT

Tu, C. C., Hsieh, T. F. and Tsai, W. H. 1991. **Effects of temperature, moisture and amendments on the occurrence of lily southern blight caused by *Sclerotium rolfsii* Sacc.** Plant Prot. Bull. 33:80-94. (Taiwan Agricultural Research Institute, Taichung, Taiwan, R.O.C.)

Lily southern blight was caused by *Sclerotium rolfsii* Sacc. When 5 dried sclerotia (Inoculum density about 2.6 sclerotia per 100 cm^3 of soil) were inoculated into soil around the bulb of lily within 1 cm, the yellowing symptom appeared within 2 weeks. Moreover, the disease severity increased gradually with increasing the number of sclerotia. On soil plate, the maximum sclerotial germination occurred at 20-28℃. The percentage of germination increased when the sclerotia were incubated under drying condition for 3 days at 20℃ and then remoistened and placed at 28℃. Consistently, the greater disease severity was obtained when the lily plants were transferred into the 28℃ condition after 1 week of incubation under 20℃. In general, the best solute water potential for sclerotial germination and mycelial growth was between -1 and -10 bars. However, with decreasing of solute water potential from -10 to -50 bars, the percentage of germination and growth rate decreased. Under the condition when tested

plants were transferred from 20 to 28℃ , the disease severity at both soil moisture treatments (15 and 30% MHC) was 0.81 aftet 4 weeks of inoculation, however, the disease development was faster at 15% than at 30% MHC. Among 21 tested chemical compounds that were amended to soil at 1% (W/W) rate, nitrogen compounds showed more inhibitory to the germination of sclerotia on soil plate than others. Sodium nitrite could completely inhibit the germination at 125 ppm nitrogen (N), ammonium bicarbonate at 250 ppm N, urea and ammonium carbonate at 500 ppm N. Ammonium acetate and ammonium citrate at 1000 ppm N also inhibited the germination completely. The percentage of sclerotial germination was decreased when 1% (W/W) chitin, chaff, bagasse, cattle manure or waste of sawdust compost used for mushroom growing was amended to soil. Moreover, the disease severity also was decreased after amendment with 0.5% (W/W) chitin, 1% (W/W) chaff or cattle manure. The effects of inorganic salts and organic matters on *Sclerotium rolfsii* and on the disease were discussed.

(Key words: lily, *Sclerotium rolfsii,* inoculum density, temperature, soil moisture, nitrogen compound, organic matter)