Bacillus safensis TC3-1S與蚵殼粉複合物應用於甘藍及洋香瓜生產之研究[1]

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摘　　要

Bacillus safensis TC3-1S與蚵殼粉複合物應用於育苗介質添加，可生產根內含有菌株TC3-1S之甘藍及洋香瓜幼苗。此複合物亦可應用於生產相對高氮(FD)及高鉀(FDA)之有機液肥，且此兩液肥中，菌株TC3-1S之菌數可達10^9 CFU/mL。甘藍基肥施用菜籽粕，搭配追施台肥1號即溶複合肥料(26-13-13)，其幼苗根內含菌株TC3-1S，較根內不含菌株TC3-1S者，可顯著提高採收鮮重達15.8%，且可提高甘藍植體之鈣、鎂及錳含量。甘藍根內不含菌株TC3-1S，追施FD液態肥及台肥1號即溶複合肥料對甘藍鮮重無顯著差異。洋香瓜種植於泥炭介質中，於追施相同液態肥條件下，根內含菌株TC3-1S與否對洋香瓜果實性狀則無顯著影響。

關鍵詞：*Bacillus safensis*、蚵殼粉、載體、根內菌、甘藍、洋香瓜

前　　言

蚵殼主成分為碳酸鈣，含有37.4%的鈣、0.59%的鈉及0.27%的鎂[7]，其表面呈多孔性，耐熱、耐壓且比重大於水。研究指出蚵殼中的有機物主要為幾丁質與蛋白質，經堆積將導致蚵殼堆積物溫度上升，顯示微生物分解有機物之現象[8]。新鮮蚵殼酸鹼度約8.4，氯化鈉含量約0.54%，蚵殼經堆積1年後，其酸鹼度會上升至9.9而鈉含量降低至0.23%[9]。前人曾自蚵殼中篩選出幾丁質分解菌如*Bacillus licheniformis* CBFOS-03[3]，另有研究發現微生物可附著於蚵殼表面生長，形成生物膜[4]，顯示微生物與蚵殼具有複合應用之潛力。內生菌促進作物生長包含生成植物賀爾蒙、酵素、溶磷、固氮及增進養分吸收[2,11,17,20]，其中，內生菌*Bacillus safensis*已有相關研究，如前人研究曾自桂花篩選內生菌*Bacillus safensis* B21應用於生物農藥之相關試驗[14]。自虎尾草根內篩選*Bacillus safensis* ZY16應用於植生復育，降解土壤油污染物[18]。*Bacillus safensis* TC3-1S可以蚵殼粉為載體，複合後應用於甜瓜育苗生產根內含此菌株之幼苗，且不影響種子發芽率[1]。本試驗持續研究*Bacillus safensis* TC3-1S與蚵殼粉複合物，應用於甘藍及洋香瓜生產之研究。

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材料與方法

一、菌株與蚵殼粉複合物製備

本試驗將蚵殼粉進行高溫高壓滅菌(121℃,15 psi)。菌株TC3-1S培養於1%糖蜜、1%菜籽粕(三木實業有限公司N-P_2O_5-K_2O 6-2-1)及0.5%酵母粉之50 ml液態培養基中，於30℃及120 rpm震盪培養6天後，取菌液與滅菌之蚵殼粉，以1: 5(W/W)比例混拌均勻後，放置於室溫備用。

二、菌株TC3-1S與蚵殼粉複合物應用於有機液肥製作

本試驗添加2 g之菌株TC3-1S與蚵殼粉複合物(複合60天)，於滅菌之1L含1%糖蜜+10%羽毛土(FD)，及1%糖蜜+5%羽毛土+2%草木灰(FDA)。羽毛土取自興隆羽毛股份有限公司(N-P_2O_5-K_2O= 12.0-0.6-0.1)於30℃經120 rpm震盪培養6天後進行菌數及培養液成分分析。

三、育苗介質水溶性養分及菌數分析

本試驗之育苗處理為(1)泥炭(處理代號為P)及(2)泥炭與菌株TC3-1S之蚵殼粉複合物混拌(以重量比5:1進行混拌，處理代號為P-TC3-1S)。此兩介質以去離子水萃(1:10)取後，分析其pH、EC值及養分含量，另以10倍稀釋塗抹於nutrient broth agar(Difco, NA)以計算介質中總菌數並依菌株TC3-1S之菌落型態得知菌數。

四、甘藍台中2號及洋香瓜台南13號育苗試驗

甘藍以128孔穴盤進行育苗，每處理3重複，1個月後調查發芽率、根長及全株植株鮮重。洋香瓜以50孔穴盤進行育苗，定植前調查發芽率、根長及全株植株鮮重。

五、根內菌分析

甘藍及洋香瓜幼苗根內菌篩選依據Moronta-Barrios等人方法並做些微修正[12]。洋香瓜苗根先經自來水沖洗，並置放於雙層擦手紙中，以去除多餘水分，取2 g根經70%酒精浸泡搖晃1 min，倒除酒精後添加1.2%次氯酸鈉溶液，以80 rpm震盪15 min後，以無菌水沖洗6次，取根至研缽中並添加3 ml無菌食鹽水(0.85%氯化鈉)，搗出汁液經連續稀釋塗抹於NA培養基，經3-6天培養後，於P-TC3-1S處理組挑選菌落型態與菌株TC3-1S相似者，經繼代純化後，抽取DNA進行BOX-PCR分析[6,15]，PCR條件為95℃ 5 min，95℃ 1 min、60℃ 1 min、72℃ 1 min 35 cycle，72℃ 7 min，以確認其為菌株TC3-1S。無菌確認為取上述最後一次無菌水洗根液100 uL，分別接種於5 mL NB及直接塗抹於NA培養基，經培養確認無菌程序是否完成。

六、甘藍田間試驗

甘藍於本場試驗田進行田間試驗，試驗田每小區1.4 m×5 m，株距50 cm，育苗方式分為播種於泥炭介質(P)及含菌株TC3-1S與蚵殼粉複合物之泥炭介質(P-TC3-1S)共兩處理；試驗每處理4重複，採逢機完全區集設計(Randomized Complete Block Design, RCBD)，每分地施用基肥菜籽粕250 kg，

依小區面積換算施用。追肥方式分為甘藍定植後澆灌FD有機液肥(依上述材料方法製作)及台肥1號即溶複合肥料共兩處理。定植後10日、22日及29日追施液態肥，皆以400倍稀釋後，每株施用200 mL。定植後39日、46日、52日追肥改以200倍稀釋後，每株施用300 mL。定植後64日採收調查鮮重、剖面長寬、糖度及甘藍植體養分分析。採收之甘藍植體進行養分分析。

七、洋香瓜介質試驗

本試驗洋香瓜幼苗P及P-TC3-1S分別定植於裝填泥炭之百合球莖籃(9.4 cm×40 cm×8.3 cm)，每種處理之幼苗種植10籃，每籃定植2株幼苗，其中5籃澆灌本試驗產製之有機液肥FD及FDA，而另5籃澆灌台肥1號及5號即溶複合肥料。施肥時期、肥料種類及用量如表一所示，果實採收期調查果實單果重、剖面長寬、果肉厚度、糖度。果實採收期採集果實及其上1葉進行葉片養分分析。

八、介質、液肥及植體養分分析

育苗介質(1:10)水萃液及有機液肥，以電極測定pH及EC，樣品之氮用微量擴散法測定[5]，磷用比色法定量[13]，鉀及鈉用火焰光度計測定(Sherwood flame photometer 410)，鈣、鎂及微量元素則用原子吸收光譜儀(Hitachi Polarized Zeeman Atomic absorption spectrophotometer Z-5000)分析。

植體先以濃硫酸及雙氧水消化分解[10]，依上敘方法測定氮、磷、鉀、鈣及鎂。而微量元素銅、錳、鋅及鐵則以1 N鹽酸反應[21]後以原子吸收光譜儀分析。

九、統計分析方法

以SAS Enterprise Guide 7.1軟體進行統計分析，以Least Significance difference(LSD)法進行比較，表中相同字母表示彼此間無顯著差異($p<0.05$)。

表一、洋香瓜不同生育時期之肥料處理
Table 1. Fertilizer treatments in different melon growth stage

Days after transplanting	Fertilizer treatment
7	Drench of 400X diluted FD liquid fertilizer and Taifer instant water soluble fertilizer NO.1, 200 mL per plant.
11	Drench of 400X diluted FD liquid fertilizer and Taifer instant water soluble fertilizer NO.1, 200 mL per plant.
14	Drench of 200X diluted FD liquid fertilizer and Taifer instant water soluble fertilizer NO.1, 200 mL per plant.
16	Drench of 200X diluted FD liquid fertilizer and Taifer instant water soluble fertilizer NO.1, 200 mL per plant.
18	Drench of 200X diluted FD liquid fertilizer and Taifer instant water soluble fertilizer NO.1, 200 mL per plant.
21	Applying 250 g compost (N-P-K=2.8-3.4-2.3) on the surface of culture media
22-24	Drench of 200X diluted FD liquid fertilizer and Taifer instant water soluble fertilizer NO.1, 200 mL per plant.
27-31	Drench of 200X diluted FD liquid fertilizer and Taifer instant water soluble fertilizer NO.1, 250 mL per plant.
34-38	Drench of 100X diluted FD liquid fertilizer and 200X diluted Taifer instant water soluble fertilizer NO.1, 250 mL per plant.
41-45	Drench of 100X diluted FD liquid fertilizer and 200X diluted Taifer instant water soluble fertilizer NO.1, 250 mL per plant.
48-52	Drench of 100X diluted FD liquid fertilizer and 200X diluted Taifer instant water soluble fertilizer NO.1, 250 mL per plant.
55-58	Drench of 100X diluted FD liquid fertilizer and 200X diluted Taifer instant water soluble fertilizer NO.5, 250 mL per plant.

結果與討論

一、有機液肥FD(A)養分分析

本試驗應用菌株TC3-1S與蚵殼粉複合物，作為液肥接菌劑，其中添加複合物於1%糖蜜及10%羽毛土，可生成相對高氮之有機液態肥，銨離子含量達2,032.5 mg/L而鉀離子含量可達360.5 mg/L。而添加於1%糖蜜、5%羽毛土及2%油棕灰，其銨離子含量達1,553.7 mg/L而鉀離子含量可達5,126.0 mg/L。此兩液態肥偏鹼性，總氮、磷酐及氧化鉀合計量皆大於1%。菌株TC3-1S可藉由蚵殼粉載體於此液肥配方中進行增殖，菌數可達10^9 CFU/mL(表二)。顯示菌株TC3-1S與蚵殼粉複合物，可作為固態菌劑之應用。

表二、菌株 TC3-1S 與蚵殼粉複合物應用於有機液肥製作之成品特性分析
Table 2. Characteristics of liquid organic fertilizer by inoculation of strain TC3-1S complexed with oyster shell powders and incubation

Treatment	pH	EC	NH_4^+	P	K	Ca	Mg	Tot N	Tot P	Tot K	Bacterial number
		dS/m	mg/L					%			$*10^9$CFU/mL
FD	8.35 ±0.05*	12.05 ±0.45	2,032.5 ±124.5	6.0 ±3.0	360.5 ±12.5	87.0 ±3.0	53.5 ±4.5	0.96 ±0.07	0.02 ±0.00	0.02 ±0.00	6.7±0.5
FDA	8.02 ±0.02	16.75 ±0.53	1,553.7 ±176.5	11.0 ±1.7	5,126.0 ±90.7	19.0 ±4.4	28.0 ±3.0	0.67 ±0.08	0.04 ±0.00	0.52 ±0.09	4.2±0.7

*Mean±S.D.

二、育苗介質菌數及水溶性養分分析

蚵殼粉複合物與泥炭混拌後，總菌數為1.1±0.2×10^7 CFU/g而菌株TC3-1S之菌數為9.2±2.5×10^6 CFU/g，純泥炭之總菌數為4.2±0.8×10^5 CFU/g。育苗介質之水溶性養分如表二所示，添加菌株TC3-1S與蚵殼粉複合物於泥炭介質中(P-TC3-1S)，可顯著增加水溶性銨、鉀、鈣、鎂及鈉含量，進而提高pH及EC值(表三)。P-TC3-1S處理組之水溶性磷明顯較低，可能為蚵殼中高水溶性鈣含量與泥炭之水溶性磷產生沉澱所致。

表三、育苗介質水溶性養分分析(1:10)
Table 3. Water soluble nutrients(1:10) in the two nursery media

Treatment	pH (1:10)	EC (1:10)	NH_4^+	NO_3^-	P	K	Ca	Mg	Cu	Mn	Zn	Fe	Na
		dS/m	ppm										
peat	5.6b	0.7b	12.0b	358.7a	194.3a	382.3b	585.0b	123.0b	0.51a	0.48a	0.38b	3.1a	47.7b
P-TC3-1S	7.5a	1.2a	83.0a	291.0a	17.0b	437.0a	769.7a	139.0a	0.51a	0.42a	0.51a	1.1b	811.0a

Significance in comparison at $P < 0.05$ (LSD test).

三、甘藍植株幼苗性狀與根內菌數分析

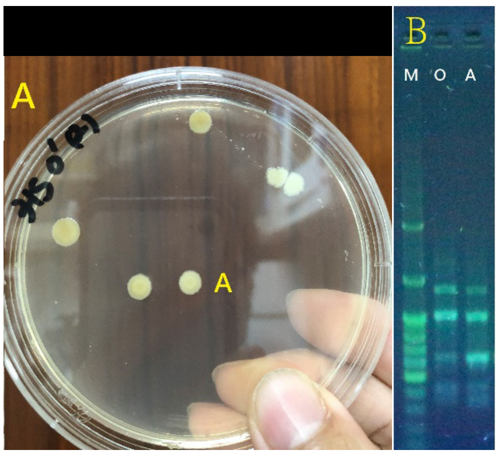
本試驗甘藍植株幼苗性狀如表四所示，其中以種植於泥炭混拌菌株TC3-1S與蚵殼粉複合物(P-TC3-1S)之幼苗性狀較佳。先前研究發現香瓜(嘉玉)播種於泥炭混拌原有蚵殼粉，香瓜發芽率及幼苗生育狀況皆較播種於泥炭處理組顯著下降[1]，然而，育苗於泥炭混拌蚵殼粉與菌株TC3-1S複合物，其香瓜發芽率及幼苗根系性狀與泥炭處理組無顯著差異，其原因為蚵殼粉與菌株TC3-1S複合後，可降低複合物之EC值、提高複合物養分含量且菌株TC3-1S可進入香瓜根內，這些效應皆有可能導致甘藍育苗於P-TC3-1S之幼苗性狀較育苗於泥炭(P)處理組佳。此外，泥炭介質混拌蚵殼粉與菌株TC3-1S複合物，可提高其養分含量，或有助於甘藍植株幼苗生長。

甘藍播種於P-TC3-1S介質中，根內菌數含量較之前香瓜(嘉玉)播種於P-TC3-1S介質之幼苗根內菌數低[1]，然而經BOX-PCR確認，根內菌為菌株TC3-1S且雜菌少(圖一)。甘藍播種於泥炭介質，其幼苗根內菌含量更少(表四)。試驗結果顯示，即使同一含菌載體，因不同作物種類，會影響根內菌數含量高低。而菌株TC3-1S依然能以蚵殼粉為載體進入甘藍台中2號之根內。

表四、甘藍育苗於泥炭及泥炭混拌蚵殼粉複合物之幼苗特性與根內菌數分析
Table 4. characteristics of cabbage seedlings and endophytic bacterial numbers seeding in peat (P) and peat mixed with strain TC3-1S complexed with osyter shell powders (P-TC3-1S)

Treatment	Root length cm	Plant height cm	Root weight g	Shoot weight g	Germination rate %	Endophyte CFU/g
P-TC3-1S	19.7a	9.0a	0.21a	0.74a	92.5a	11.0a
P	12.1b	6.9b	0.10b	0.52b	91.9a	1.3b

Significance in comparison at P < 0.05 (LSD test).



圖一、甘藍育苗於 P-TC3-1S(圖 A)之根內菌落及 BOX-PCR 圖譜(圖 B)，M:Bio 100 DNA marker、O:菌株 TC3-1S、A 為圖 A 所標示之菌落。
Fig. 1. The endophytic colonies of cabbage seedlings by seeding in peat mixed with P-TC3-1S (Fig. A). Box-PCR profile M: Bio100 marker, O: B. *Safensis* TC3-1S, A: Colony present in the Fig. A was subjected to BOX-PCR (Fig. B).

四、甘藍採收調查

甘藍基肥施用菜籽粕之試驗結果如表五所示，甘藍育苗於泥炭(P)及含菌株TC3-1S與蚵殼粉複合物之泥炭介質(P-TC3-1S)，追施FD液態肥對甘藍鮮重無顯著差異。然而追施台肥1號即溶複合肥料，則以TC3-1S-C處理組甘藍鮮重最高，且與其它處理組達顯著差異，但糖度較Peat-C處理組低。以P育苗處理組(Peat-FD及Peat-C)，搭配澆灌FD或台肥1號即溶複合肥料對甘藍鮮重無顯著影響，顯

示以少量多次施肥方式，追施相對低肥分之FD液肥，可發揮肥效，可能原因為FD液態肥中，含有菌株TC3-1S，其蛋白質分解能力或有助於菜籽粕分解而釋放養分。此外，追施FD液態肥具有減少總投入肥料量及此施肥模式可應用於友善農耕之優點。前人研究發現根內真菌*Ramichloridium cerophilum*可促進白菜幼苗生長[19]，另可增加白菜根系生長並提高葉片抗氧化酵素活性，提高其抗旱能力[16]。顯示，根內菌於十字花科之應用，已有陸續研究，本試驗發現根內菌株TC3-1S於追施即溶化肥條件下，其甘藍鮮重最重，可能為菌株TC3-1S具生成IAA能力，有助於根系生長，增加吸收較高養分含量之化學肥料量，進而促進甘藍生產。

表五、不同處理之甘藍採收調查
Table 5. Cabbage harvested investigation among different treatments

Treatment	Fresh weight g	Head length cm	Head width cm	TSS °brix
TC3-1S-FD	1,285.8b	12.9c	19.2c	5.7b
Peat-FD	1,405.6b	13.8b	20.2b	5.9ab
TC3-1S-C	1,640.3a	14.5a	21.9a	5.7b
Peat-C	1,416.1b	13.7b	19.8bc	6.0a

Significance in comparison at $P < 0.05$ (LSD test).
TC3-1S-: cabbage seedlings growth in peat mixed with strain TC3-1S complexed with oyster shell powders and transfer to field.
Peat-: cabbage seedlings growth in peat and transfer to field.
-FD: Drench of liquid organic fertilizer (FD).
-C: Drench of liquid instant chemical fertilizer NO.1.

五、甘藍植體養分分析

甘藍植體分析如表六所示，以幼苗根內含菌株TC3-1S移植於田間搭配澆灌即溶化學肥料處理組(TC3-1S-C)，其植體鈣、鎂及錳含量較高，是否因此而導致甘藍產量較高，仍需往後重複試驗以做驗證。

六、洋香瓜幼苗植株性狀與根內菌數分析

本試驗洋香瓜(臺南13號)植株幼苗性狀如表七所示，其中以種植於泥炭混拌菌株TC3-1S與蚵殼粉複合物(P-TC3-1S)之幼苗性狀較佳，可能與甘藍幼苗根內含菌株TC3-1S之生長較佳有相同效應。此外，鈉含量提高至811 ppm尚未影響幼苗生育。洋香瓜育苗於泥炭(P)及P-TC3-1S，根內菌數以P處理組較高，育苗於P-TC3-1S中，根內菌株TC3-1S菌數為$4.2 \pm 0.45 \times 10^2$ CFU/g，菌株TC3-1S之判定除以菌落型態與菌株TC3-1S一致外，另以BOX PCR分析(圖二)進行雙重確認後，判定為菌株TC3-1S。

表六、不同處理之甘藍植體養分分析

Table 6. Cabbage plant nutrient analysis among different treatments

Treatment	N	P	K	Ca	Mg	Cu	Mn	Zn	Fe
	%					ppm			
TC3-1S-FD	1.5a	0.30a	2.3a	0.56b	0.13b	7.0a	10.3ab	10.5a	26.0a
Peat-FD	1.6a	0.32a	2.4a	0.56b	0.14b	4.8a	8.3b	11.5a	26.3a
TC3-1S-C	2.0a	0.34a	2.5a	0.64a	0.16a	4.3a	11.3a	12.3a	29.3a
Peat-C	2.0a	0.31a	2.3a	0.56b	0.14b	4.3a	8.5b	13.0a	26.3a

Significance in comparison at $P < 0.05$ (LSD test).

TC3-1S-: cabbage seedlings growth in peat mixed with strain TC3-1S complexed with oyster shell powders and transfer to field.

Peat-: cabbage seedlings growth in peat and transfer to field.

-FD: Drench of liquid organic fertilizer (FD).

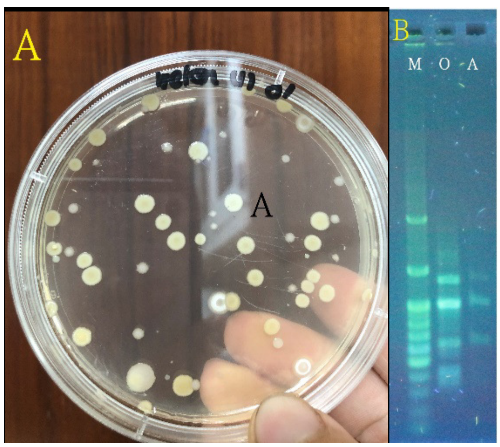
-C: Drench of liquid instant chemical fertilizer NO.1.

表七、洋香瓜育苗於泥炭及泥炭混拌蚵殼粉複合物之幼苗特性與根內菌數分析

Table 7. Characteristics of muskmelon seedlings and endophytic bacterial numbers seeding in peat (P) and peat mixed with strain TC3-1S complexed with osyter shell powders (P-TC3-1S)

Treatment	Root length	Plant height	Root weight	Shoot weight	Germination rate	Endophytic
	cm	cm	g	g	%	CFU*10^3/g
P-TC3-1S	49.6a	18.0a	0.69a	3.3a	98.0a	0.77b
P	37.5a	14.7b	0.42b	2.2b	91.3a	7.45a

Significance in comparison at $P < 0.05$ (LSD test).



圖二、洋香瓜育苗於 P-TC3-1S 之根內菌落型態(圖 A)及 BOX-PCR 圖譜(圖 B)，M: Bio 100 DNA marker、O: 菌株 TC3-1S 及 A 為圖 A 所標示之菌落。

Fig. 2. The endophytic colonies of muskmelon seedlings by seeding in peat mixed with P-TC3-1S (Fig. A). Box-PCR profile M: Bio100 marker, O: B. *Safensis* TC3-1S, A: Colony present in the Fig. A was subjected to BOX-PCR (Fig. B).

七、果實採收調查

洋香瓜果實採收調查如表八所示，洋香瓜幼苗根內含菌株TC3-1S，於施用相同液態肥條件下，其單果重似有增加趨勢，但與育苗於純泥炭處理組，彼此間無顯著差異(TC3-1S-C與Peat-C；TC3-1S-FDA與Peat-FDA)。此外，統計上P-C與P-TC3-1S-FDA未達顯著差異，而P-C卻與P-FDA達顯著差異，顯示，洋香瓜幼苗含菌株TC3-1S於追施相對低肥分之有機液態肥條件下，有提高果實重量之趨勢。追施本試驗產製之FDA液態肥，因其肥分低，單果重較追施即溶肥料處理組低，或許泥炭介質添加較多量之有機肥質料條件下，可如同甘藍試驗，使此含菌有機液肥發揮肥效。

表八、不同處理洋香瓜果實性狀調查
Table 8. Muskmelon fruit characteristics among different treatments

Treatment	Fruit weight g	Pulp weight g	Fruit cross length cm	Fruit cross width cm	Pulp thickness cm	TSS °brix
TC3-1S-C	1651.5a	1548.2a	15.8a	14.6a	4.1a	16.5a
Peat-C	1635.4ab	1526.0a	14.5ab	14.5a	4.2a	15.4a
TC3-1S-FDA	1362.5bc	1267.8b	14.2b	13.5b	3.7a	15.5a
Peat-FDA	1281.9c	1202.8b	13.6b	13.3b	3.9a	15.8a

Significance in comparison at $P < 0.05$ (LSD test).
TC3-1S-: cabbage seedlings growth in peat mixed with strain TC3-1S complexed with oyster shell powders and transfer to peat.
Peat-: cabbage seedlings growth in peat and transfer to peat.
-FDA: Drench of liquid organic fertilizer FD and FDA.
-C: Drench of liquid instant chemical fertilizer NO.1.

八、洋香瓜葉片養分分析

洋香瓜葉片養分分析如表九所示，各處理之葉片養分以幼苗根內含菌株TC3-1S而澆灌FDA有機液肥之葉片鋅及鐵含量較高，可能為有機液肥額外含有微量元素，且根內含菌株TC3-1S或有助於此兩微量元素之吸收，然而，果實性狀並無顯著差異，未來於椰纖介質系統或土耕系統將評估洋香瓜根內含有菌株T3-1S之生長效益及澆灌有機液肥之葉片微量元素含量變化。

表九、不同處理之洋香瓜葉片養分分析
Table 9. Muskmelon leaf nutrient analysis among different treatments

Treatment	N	P	K	Ca	Mg	Cu	Mn	Zn	Fe
	%					ppm			
TC3-1S-C	1.9a	0.55a	3.8a	5.5a	1.2a	3.8a	74.0a	38.8b	102.0b
Peat-C	2.0a	0.67a	3.7a	4.2a	0.91a	4.5a	73.3a	54.3ab	124.8ab
TC3-1S-FDA	0.95b	0.32b	3.8a	4.4a	0.97a	5.0a	76.0a	70.8a	148.3a
Peat-FDA	0.94b	0.35b	4.0a	3.6a	0.92a	4.0a	76.8a	42.0ab	115.0ab

Significance in comparison at $P < 0.05$ (LSD test).
TC3-1S-: cabbage seedlings growth in peat mixed with strain TC3-1S complexed with oyster shell powders and transfer to peat.
Peat-: cabbage seedlings growth in peat and transfer to peat.
-FDA: Drench of liquid organic fertilizer FD and FDA.
-C: Drench of liquid instant chemical fertilizer NO.1.

結　　論

蚵殼粉可作為菌株TC3-1S之載體，複合物應用為育苗介質添加，可生產根內含此菌株之甘藍(台中2號)及洋香瓜(台南13號)幼苗。甘藍幼苗移植田間，搭配澆灌台肥1號即溶複合肥料可提高採收鮮重，甘藍根內不含菌株TC3-1S搭配澆灌台肥1號即溶複合肥料或FD有機液肥，甘藍鮮重無顯著差異，顯示以多次澆灌方式，可發揮FD液態肥之效果。洋香瓜種植於泥炭介質，幼苗根內含菌株TC3-1S與否，對果實性狀影響不大。可能泥炭介質相較於土壤環境單純，根內菌較未能發揮效果。作物幼苗根內含菌株TC3-1S及其是否發揮增產效應，似受栽培作物種類、品種、肥料、栽培環境及模式等之影響。

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Application of Oyster Shell Powders Complexed with *Bacillus safensis* TC3-1S in Production of Cabbage and Muskmelon[1]

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ABSTRACT

Oyster shell powders can be used as a carrier for *Bacillus safensis* TC3-1S for producing solid bacterial complex. Applying the complex in nursery medium mixture may help to increase the colonization of strain TC3-1S in cabbage and muskmelon seedlings. Applying the complex as an inoculant can produce relative high nitrogen contained (FD) and relative high potassium contained liquid organic fertilizer (FDA), both with the bacterial number of strain TC3-1S higher than 10^9 cfu/ml. Transfering cabbage seedlings with or without endophytic strain TC3-1S into field with applying rapeseed meal as base fertilizer combined with drench of instant chemical fertilizer (26-13-13), increased cabbage weight (increase 15.8%) and higher contents of plant calcium, magnesium and manganese was also found in the seedlings with endophytic strain TC3-1S. Planting the cabbage seedlings without endophytic strain TC3-1S in field with rapeseed meal as base fertilizer and drench of two fertilizers, the harvested cabbage weight was no significant difference between drench of instant chemical fertilizer (26-13-13) and FD liquid organic fertilizer. The result of melon experiment showed that the fruit characteristics were not affected by endophytic strain TC3-1S but only influenced by different fertilizers.

Key words: *Bacillus safensis*, oyster shell powder, carrier、endophytic bacterium, cabbage, muskmelon

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