應用微生物製劑提升洋桔梗生產及切花品質之研究[1]

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摘　　要

本試驗探討澆灌3種微生物製劑對促進洋桔梗生長及切花品質之影響。澆灌貝萊斯芽孢桿菌Tcb43及木黴菌TCT168製劑可提高洋桔梗株高及地上部鮮重，田間開3-7朵花之開花率以施用地衣芽孢桿菌TCLigB製劑之65%及木黴菌TCT168製劑之95%為最佳，顯著高於對照組0%。第8天切花瓶插性狀之分析結果，顯示未除蕾處理組以菌株Tcb43製劑具較佳之開花率，且花苞萎凋率顯著低於對照組，除蕾處理組則以菌株TCT168及TCLigB製劑之開花率與鮮重顯著高於對照處理組，葉片失水率則顯著低於對照組。第15天切花瓶插結果顯示未除蕾處理組之菌株TCT168製劑之開花率與鮮重顯著高於對照組，而花苞萎凋率則顯著低於對照組，除蕾處理組則以菌株TCT168與TCLigB製劑處理組之開花率與鮮重顯著高於對照組，葉片失水率顯著低於對照組，而花苞垂頸率則以TCT168製劑處理組最低。施用木黴菌可顯著提高多種元素含量，其中磷、銅及鋅含量於葉、莖及花中皆顯著提升，試驗結果顯示施用木黴菌TCT168製劑具最佳提升洋桔梗切花品質之效果。

關鍵字：洋桔梗、木黴菌、芽孢桿菌、瓶插壽命

前　　言

洋桔梗(*Eustoma russellianum*)為我國重要切花產品，產區主要集中於彰化縣、雲林縣、嘉義縣及臺南市，農友普遍以土耕栽培，然而因化學肥料過量使用，易導致土壤鹽化，不利根系生長，連續種植相同作物不僅容易導致特定病蟲為害，且洋桔梗生長過程，因根系分泌多種酸性物質，如馬來酸(maleic acid)及苯甲酸(benzoic acid)已被證實會抑制自體生長(4)。

微生物因具多種功能，如耐鹽、降解有機物質作為能量來源與碳骨架、分泌促進根系生長物質等，如某些自鹽土中篩選之細菌如 *Pseudomonas* sp. 與 *Bacillus* sp.可提高植物抗鹽能力與促進植物生長，如白三葉草(6)、小麥(8)及玉米(9)。放線菌可有效降解土壤中之苯甲酸(2)，及促進作物生長等(5)。本試驗探討洋桔梗種植於連續耕作土壤，生育過程澆灌微生物菌液對洋桔梗生育及切花品質之影響。

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材料與方法

一、微生物製劑之配製

本試驗(1)地衣芽孢桿菌製劑(*Bacillus licheniformis*)：利用地衣芽孢桿菌TCLigB培養於滅菌之1%糖蜜及0.5%菜籽粕之液態培養基，於室溫經120 rpm震盪4天培養後備用(菌數達1×10^8 CFU/ml以上)。(2)貝萊斯芽孢桿菌製劑(*Bacillus velezensis*)：貝萊斯芽孢桿菌Tcb43菌株，培養於滅菌後之培養基

(5%以下大豆蛋白、砂糖及微量蔬菜油)，經10 l桌上型發酵槽，以400 rpm轉速、溫度30℃，通氣量0.5 vvm進行培養65小時後，取樣經分析菌量達1×10^8 CFU/ml以上，收起備用。(3)木黴菌製劑(*Trichoderma asperelloides* TCT168)：木黴菌TCT168菌種先培養於稻穀培養基，於10天後備用。木黴菌液肥配製：則是取10 g木黴菌稻穀菌種添加於液肥原料(配方為1 kg乳清蛋白＋0.5 kg海草粉＋0.3 kg矽藻土＋150 ml蝦蟹殼粉＋2 kg糖蜜＋20 l水，製程為糖蜜溶於水，糖蜜除外之資材裝填於過濾袋)中發酵，製程為糖蜜除外之資材裝填於過濾袋中，放入容器中，添加糖蜜與水至20l，以濾袋懸浮發酵方式發酵14天後取得木黴菌液肥備用。田間施用時以50 g稻穀菌種加入5 l水中，將孢子調製成懸浮液，加入製備之木黴菌液肥中，使液肥中木黴菌孢子最終濃度在1×10^8 spore/ml。

二、洋桔梗田間試驗

試驗田位於彰化縣北斗鎮之簡易塑膠布溫室，洋桔梗試驗品種為‘女王白’ (Renina2-white)，於2022年8月12日定植，微生物製劑澆灌處理為(1)貝萊斯芽孢桿菌Tcb43、(2)木黴菌TCT168、(3)地衣芽孢桿菌TCLigB及(4)不額外施用微生物製劑。施用微生物製劑之處理於定植一週後每週澆灌製劑，其中木黴菌以100倍稀釋後澆灌，貝萊斯芽孢桿菌及地衣芽孢桿菌則以200倍稀釋澆灌，以植株頂部澆灌方式均勻澆施於畦面與植株上，每週每株洋桔梗澆灌30 ml，總共澆灌9週。每處理之試驗畦寬50 cm，畦長30 m，每處理10 m長，洋桔梗種植行株距10 cm，每菌劑處理以3重複進行，試驗設計採隨機完全區集設計。

三、洋桔梗生育及切花調查

洋桔梗於定植後第 3、6、9 週調查生長及開花性狀項目，包含株高、葉對數、節間長、葉長、葉寬、莖徑、葉綠素讀值、鮮重、花下節位數、分枝數、花苞數、開花數、總花數、花徑、花色及開花率。切花瓶插調查項目包含莖曲度、鮮重、花苞數、開花數、總花數、花+苞開放率、花+苞垂頸率、花+苞萎凋率、葉片失水率及瓶插壽命。

四、土壤肥力分析

土壤分析為樣品先經風乾處理，經 2 mm 篩網過篩後測定土壤理化學性質。土壤 pH 及電導度以水:土比 5:1 (w/w)，分別以電極法測定。土壤有機質含量採用總有機碳分析儀(Elementar vario MAX C)測定。以 1 M 醋酸銨(pH7.0)，土:溶液比 1:10 抽出[10,11]，濾液用感應耦合電漿光譜分析儀

(Inductively Coupled Plasma-Atomic Emission Spectrometry; ICP-AES，HORIBA JOBIN-YVON ULTIMA 2)測土壤交換性鉀、鈣及鎂含量。以 Bray No.1 方法抽取[13]，並用感應耦合電漿光譜分析儀測土壤有效性磷。土壤微量元素以 0.1 N 鹽酸萃取[3]並以感應耦合電漿光譜分析儀測定。

五、植體養分分析

植體以濃硫酸及雙氧水消化分解[12]，氮用微量擴散法測定[7]，磷用比色法定量[13]，鉀用火焰光度計測定(Sherwood flame photometer 410)，鈣及鎂則用原子吸收光譜儀(Hitachi Pola rized Zeeman Atomic absorption spectrophotometer Z-5000)分析。微量元素銅、錳、鋅及鐵則以 1 N 鹽酸反應[15]並以原子吸收光譜儀分析。

六、統計分析

以SAS Enterprise Guide 7.1軟體進行統計分析，以Least significance difference (LSD)法進行比較($p<0.05$)。

結果與討論

一、試驗前土壤肥力

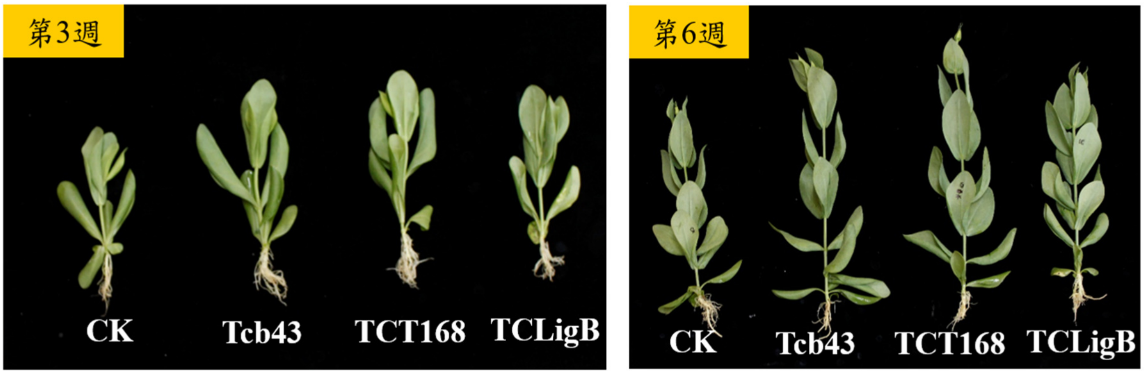
洋桔梗連作田試驗前土壤性質為pH7.8、EC 0.9 dS/m、有機質2%、磷59 (mg/kg)、鉀269 (mg/kg)、鈣3,656 (mg/kg)、鎂289 (mg/kg)、鈉103 (mg/kg)、銅8 (mg/kg)、錳119 (mg/kg)、鋅12 (mg/kg)及鐵383 (mg/kg)。試驗田土壤偏鹼，EC值略高，依據前人研究指出，土壤電導度在0.8-1.5 dS/m時，對多數作物生長有不良的影響(三好洋,1978)，此外本試驗田有機質不足3%，磷含量偏低，鈣含量較高。

二、洋桔梗生育調查

本試驗澆灌之微生物製劑，菌數皆達1×10^8 CFU/ml以上，施用微生物對洋桔梗‘女王白’生育調查外觀表現如圖一所示，生育調查如表一所示，於第3週調查發現澆灌3種微生物皆可提高洋桔梗株高及地上部鮮重，其中以澆灌貝萊斯芽孢桿菌Tcb43及木黴菌TCT168製劑可顯著增加洋桔梗節間長，進而增加其株高。第6週調查結果之株高、節間長與地上部鮮重與第3週結果具相同趨勢，且葉長×葉寬、葉徑及葉綠素讀值皆高於對照處理組(CK)，此外，澆灌菌株Tcb43及TCLigB製劑則可較CK處理組，顯著增加洋桔梗葉對數。

施用微生物製劑對洋桔梗‘女王白’開花調查外觀表現如圖二及表三所示，切花生育調查結果如表二所示，而開花特性如表三所示，切花生育結果以Tcb43及TCT168製劑處理組顯著優於對照組，未除蕾之開花特性則以處理木黴菌TCT168製劑顯著優於對照組，如花苞數、開花數、總花數及花徑；除蕾開花特性仍以木黴菌處理組最佳，花色則各處理皆無差異。

施用微生物製劑對除蕾洋桔梗開花率之影響如表四所示，Tcb43處理組以未開花、開1朵及2朵花比例較高；TCLigB製劑處理組為開2朵、3朵及4朵花比例最高；而TCT168製劑處理組則為開4朵-7朵比例較高，顯示木黴菌TCT168製劑具增進洋桔梗生育及開花特性之應用潛力。



圖一、微生物製劑處理對洋桔梗‘女王白’生長之外觀表現。

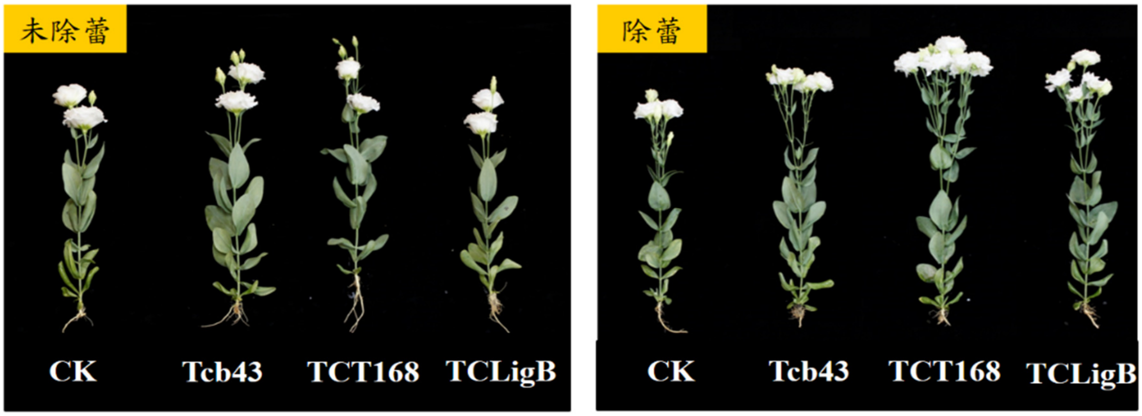
Fig. 1. The appearance of Eustoma ‘Reina White’ treated with or without different microbial suspensions at the 3^{rd} and 6^{th} weeks.

表一、微生物對土耕洋桔梗‘女王白’於種植後第 3 週及第 6 週之植株生育特性

Table1. Growth characteristics of Eustoma by applying different microbial suspensions at the 3^{rd} and 6^{th} weeks after planting

Weeks after plantation	Microbial treatment	Plant height (cm)	Number of pair leaf	Intersection length (cm)	Length X width of leaf (cm^2)	Leaf diameter (mm)	Chlorophyll value	Fresh weight of aboveground (g)
3	CK	8.3 c[1]	4.5 ab	1.9 b	---	---	---	1.7 c
	Tcb43	10.7 a	4.3 b	2.5 a	---	---	---	2.4 b
	TCT168	10.8 a	4.3 b	2.6 a	---	---	---	2.7 a
	TCLigB	9.8 b	4.8 a	2.1 b	---	---	---	2.3 b
6	CK	22.3 d	7.9 c	2.8 c	21.5 c	2.8 c	47.3 b	7.5 c
	Tcb43	28.9 b	8.4 ab	3.5 b	25.1 b	3.1 b	50.4 a	10.0 b
	TCT168	31.3 a	8.1 bc	3.9 a	33.2 a	3.2 a	50.1 a	12.8 a
	TCLigB	25.3 c	8.5 a	3.0 c	25.4 b	3.1 b	50.6 a	9.6 b

[1]Mean separation within columns and treatments by LSD test at $P < 0.05$ (n=16).



圖二、微生物製劑處理對洋桔梗‘女王白’開花之外觀表現。

Fig. 2. The flower appearance of Eustoma ‘Reina White’ treated with or without different microbial suspensions.

圖三、施用不同微生物製劑對土耕洋桔梗‘女王白’田間開花外觀表現。

Fig. 3. The flower appearance of Eustoma treated with or without different microbial suspensions in experimental field.

表二、微生物製劑對土耕洋桔梗‘女王白’開花之影響

Table 2. Plant characteristics of Eustoma ‘Reina White’ in flower stage by applying different microbial suspensions

Treatment	Days of cut flower	Microbial treatment	Plant height (cm)	Number of leaf pair	Intersection length (cm)	Length × width of leaf (cm^2)	Leaf diameter (mm)	Chlorophyll value	Fresh weight of aboveground (g)
No-disbub	62	CK	43.9 c[1]	9.1 c	4.8 c	30.9 bc	3.5 c	52.3 c	24.6 c
		Tcb43	53.4 b	9.6 ab	5.6 b	33.5 b	3.7 b	55.8 b	29.8 b
		TCT168	59.5 a	10.1 a	5.9 a	42.5 a	4.1 a	60.4 a	39.3 a
		TCLigB	44.3 c	9.3 bc	4.8 c	26.9 c	3.4 c	54.2 bc	21.5 c
Disbub	84	CK	51.6 d	9.8 c	5.3 c	33.7 c	3.7 c	56.1 a	37.0 d
	84	Tcb43	59.3 c	10.3 bc	5.8 b	34.0 c	3.7 c	56.2 a	43.0 c
	77	TCT168	69.8 a	11.3 a	6.3 a	47.4 a	4.3 a	58.1 a	62.6 a
	84	TCLigB	64.3 b	10.9 ab	5.9 ab	42.6 b	4.1 b	56.3 a	53.9 b

[1]Mean separation within columns and treatments by LSD test at $P < 0.05$ (n=16).

表三、微生物製劑對土耕洋桔梗‘女王白’切花採收期植株性狀之影響

Table 3. Plant characteristics of Eustoma in harvested time among application of different microbial suspensions

Treatment	Days of harvest after planting	Microbial treatment	Node numbers under flower	Branch number	Bud number	Open flower number	Sum of flower	Flower diameter (cm)	Flower color (RHS)
No-disbub	62	CK	7.87 b[1]	1.5 b	1.7 b	2.0 b	3.7 c	7.5 b	NN155D
		Tcb43	8.06 ab	1.8 b	2.1 b	2.1 ab	4.3 b	8.0 a	NN155D
		TCT168	8.38 a	1.5 b	3.1 a	2.3 a	5.4 a	8.0 a	NN155D
		TCLigB	8.00 b	2.4 a	1.8 b	2.0 b	3.8 c	7.4 b	NN155D
Disbub	84	CK	9.25 b	1.7 c	3.6 b	2.3 d	5.9 c	6.5 c	NN155D
	84	Tcb43	9.56 ab	2.0 b	3.8 b	2.9 c	6.8 b	7.4 b	NN155D
	77	TCT168	10.56 a	2.4 a	4.1 a	4.8 a	8.8 a	8.5 a	NN155D
	84	TCLigB	9.31 b	2.3 ab	3.9 b	3.6 b	7.4 b	8.2 a	NN155D

[1]Mean separation within columns and treatments by LSD test at $P < 0.05$ (n=16).

表四、微生物製劑對土耕洋桔梗‘女王白’於種植後第 11 週之開花率(%)(除蕾)
Table 4. Flower rate (%) of Eustoma (disbub) by applying different microbial suspensions at the 11th weeks after planting

Microbial strain	No flower open	Open 1 flower	Open 2 flower	Open 3 flower	Open 4 flower	Open 5 flower	Open 6 flower	Open 7 flower
	%							
CK	85 a[1]	10 a	5 c	0 c	0 b	0 c	0 b	0 b
Tcb43	65 b	20 a	15 b	0 c	0 b	0 c	0 b	0 b
TCT168	0 c	0 c	5 c	20 b	30 a	30 a	5 a	10 a
TCLigB	0 c	10 b	25 a	30 a	30 a	5 b	0 b	0 b

[1]Mean separation within columns and treatments by LSD test at $P < 0.05$ (n=16).

表五、微生物製劑對土耕洋桔梗‘女王白’切花瓶插第 1 天之影響
Table 5. Flower characteristics of Eustoma in vase at the first day among different treatments

Plant treatment	Microbial treatment	curvature of shoot (angle)	Fresh weight (g)	Bud number	Open flower number	Sum of flower
No-disbub	CK	8.8 b[1]	14.7 c	1.4 b	2.0 a	3.4 b
	Tcb43	11.0 a	16.6 b	1.9 b	2.0 a	3.9 b
	TCT168	12.1 a	20.9 a	3.0 a	2.0 a	5.0 a
	TCLigB	11.3 a	13.8 c	1.5 b	2.0 a	3.5 b
Disbub	CK	11.6 b	21.0 b	3.2 b	2.0 c	5.2 b
	Tcb43	13.4 a	24.3 b	3.2 b	2.8 b	5.9 b
	TCT168	13.8 a	36.8 a	3.6 a	3.4 a	7.0 a
	TCLigB	12.8 ab	29.9 ab	2.9 b	2.8 b	5.7 b

[1]Mean separation within columns and treatments by LSD test at $P < 0.05$ (n=16).

三、洋桔梗切花瓶插調查

洋桔梗切花瓶插第1天之調查結果如表五所示，未除蕾之莖曲度以CK處理組最低，鮮重以Tcb43及TCT168製劑處理組較重，花苞數及總花數以TCT168處理組較佳。洋桔梗除蕾處理組則以CK之莖曲度最低，TCT168製劑處理組鮮重最重，花苞數以TCT168製劑處理組最多，開花數則施用3種微生物皆高於對照處理組，總花數以TCT168製劑處理組最高。

洋桔梗切花瓶插第8天未除蕾處理組，以Tcb43製劑處理組具較佳開花品質，如開花率與鮮重均顯著高於對照組，而失水率及花苞萎凋率低於對照組，除蕾處理組則以製劑TCT168及TCLigB之開花率與鮮重顯著高於對照處理組，葉片失水率則顯著低於對照組，萎凋率以製劑Tcb43最佳。洋桔梗切花瓶插第15天，未除蕾處理組之製劑TCT168之開花率與鮮重顯著高於對照組，而花苞萎凋率則顯著低於對照組，以花苞萎凋率及鮮重而言製劑TCT168較具應用性，除蕾處理組則以製劑TCT168與TCLigB處理組之開花率與鮮重顯著高於對照組，而葉片失水率顯著低於對照組，而花苞垂頸率則以TCT168製劑處理組最低，花苞萎凋率以Tcb43製劑處理組最低(表六)。

表六、微生物製劑對土耕洋桔梗‘女王白’切花瓶插之影響
Table 6. Flower characteristics of Eustoma in vase among different treatments

Vase day	Treatment	Microbial strain	Flower open rate (%)	Plant fresh weight (g)	Flower wither rate (%)	Flower lodging rate (%)	Leaf water loss rate (%)	Vase life
8	No-disbub	CK	69.2 b[1]	16.5 c	24.8 a	0.0 a	38.5 a	---
		Tcb43	80.0 a	18.5 b	14.5 b	0.0 a	26.7 b	---
		TCT168	71.6 b	23.3 a	24.4 a	0.0 a	7.1 d	---
		TCLigB	70.8 b	15.2 c	23.5 a	0.0 a	16.7 c	---
	Disbub	CK	49.8 c	20.2 c	21.2 a	0.0 a	31.2 a	---
		Tcb43	58.8 b	24.4 c	10.2 b	0.9 a	18.8 b	---
		TCT168	75.8 a	38.2 a	18.3 a	0.0 a	0.0 c	---
		TCLigB	76.6 a	30.0 b	18.6 a	0.0 a	6.3 c	---
15	No-disbub	CK	80.8 b	11.6 bc	93.1 a	90.0 a	100.0 a	12.1 a
		Tcb43	96.7 a	13.0 b	94.7 a	81.3 b	100.0 a	12.7 a
		TCT168	91.1 a	15.4 a	80.0 b	90.0 a	100.0 a	12.8 a
		TCLigB	87.5 a	10.5 c	88.3 ab	82.5 b	100.0 a	13.0 a
	disbub	CK	60.3 c	14.1 c	97.0 a	99.1 a	100.0 a	12.0 a
		Tcb43	73.0 b	16.8 c	88.2 b	97.2 a	100.0 a	12.1 a
		TCT168	87.0 a	29.4 a	91.2 ab	86.5 b	75.0 b	12.4 a
		TCLigB	86.5 a	22.1 b	96.6 a	96.5 a	81.3 b	12.3 a

[1]Mean separation within columns and treatments by LSD test at $P < 0.05$ (n=16).

四、洋桔梗植體養分分析

洋桔梗切花期之植體養分分析如表七所示，區分成葉片、花朵及莖，本試驗結果顯示施用木黴菌TCT168製劑可顯著提高洋桔梗切花品質，施用其他兩株芽孢桿菌，相較對照組其植體養分含量則互有高低，與木黴菌製劑整體提高植體養分含量結果不同。施用木黴菌製劑之葉片養分含量除氮與鐵外皆較對照組高；花朵以磷、鉀、銅、鋅含量較對照組高；而莖部則以磷、銅及鋅含量高於對照組，整體而言施用木黴菌製劑可顯著提高植體之磷、銅及鋅含量。前人研究發現，洋桔梗經葉噴銅鋅可提高株高、葉片數及莖徑，且可提早10天開花[14]，與本試驗發現施用木黴菌製劑對洋桔梗促進生長之效應相近，推測施用木黴菌製劑可提高根系對銅與鋅吸收，進而提高洋桔梗切花品質。

表七、洋桔梗切花期葉片、花及莖營養元素分析

Table 7. The elemental nutrients lontena of Eustoma in leaf, flower and stem

Plant part	Microbial treatment	N	P	K	Ca	Mg	Cu	Mn	Zn	Fe
		(%)					(ppm)			
Leaf	CK	3.38ab[1]	0.18c	2.92 b	0.82 b	0.72 c	19.5 b	55.0 c	6.0 b	125.0 b
	Tcb43	3.00 b	0.20b	3.36 a	0.78 b	0.74 c	18.0 c	52.0 d	6.0 b	103.0 b
	TCT168	3.00 b	0.33a	3.68 a	0.96 a	0.85 a	21.0 a	59.0 b	9.0 a	123.0 b
	TCLigB	3.58a	0.19bc	2.64 b	0.81 b	0.79 b	17.0 d	61.0 a	6.0 b	181.0 a
Flower	CK	1.84 a	0.23 b	1.61 b	0.30 a	0.24 a	6.0 b	14.0 a	8.0 b	24.0 b
	Tcb43	1.87 a	0.22 c	1.59 b	0.27 ab	0.24 a	7.0 b	12.5 b	9.0 b	26.0 ab
	TCT168	1.58 a	0.25 a	1.66 a	0.26 ab	0.22 b	9.0 a	11.0 c	15.0 a	27.0 a
	TCLigB	1.84 a	0.23 bc	1.61 b	0.24 b	0.22 b	6.0 b	12.0 b	8.0 b	24.5 ab
Stem	CK	1.01 a	0.09 b	1.89 a	0.27 a	0.23 a	3.5 bc	5.0 a	2.5 b	10.5 a
	Tcb43	0.87 a	0.09 b	1.96 a	0.23 a	0.19 a	3.0 c	4.0 a	3.0 ab	7.0 a
	TCT168	0.81 a	0.15 a	1.94 a	0.26 a	0.20 a	5.0 a	3.5 a	4.0 a	8.5 a
	TCLigB	1.06 a	0.10 b	1.98 a	0.27 a	0.22 a	4.0 b	4.5 a	3.5 ab	13.5 a

[1]Mean separation within columns and treatments by LSD test at P < 0.05 (n=16).

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Research on Application of Microbial products in Increasing Productivity of Eustoma and Quality of the Cut Flowers[1]

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ABSTRACT

In the experiment, three different microbial products were applied in Eustoma planted in the soil field for understanding their effects in increasing productivity and quality of cut flower. Drench of microbial products of *Trichoderma* sp. TCT168 and *Bacillus velezensis* Tcb43 can increase plant height and aboveground fresh weight. Higher flower open rate of Eustoma among 3-7 flower open in the field was found in the treatments with drench of microbial products of *Trichoderma* sp. TCT168 as 95% followed by 65% of *Bacillus licheniformis* TCLigB and 0% of CK treatment without application of microbial products. The characteristics of cut flowers in vase among different treatments were determined. At the 8th day, in treatments without disbub, the flowering rate was higher but flower withering rate was lower in the treatment of applying microbial products of strain Tcb43 compared with no microbial application; in disbub treatments, flowering rate and aboveground fresh weight were higher but dehydration rate of leaf was lower found in the treatment of applying microbial products of strain TCT168 and TCLigB compared with no microbial application. At the 15th day, in treatments without disbub, flowering rate and aboveground fresh weight were higher but flower withering rate was lower in the treatment of applying microbial products of strain TCT168 compared with no microbial application. In disbub treatments, flowering rate and aboveground fresh weight were higher but dehydration rate of leaf was lower found in the treatment of applying microbial products of strain TCT168 and TCLigB compared with no microbial application. Lower lodging rate was also found in the treatment of

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applying microbial products of strain TCT168. Compared with CK, applying microbial products of strain TCT168 can increase concentration of many elemental nutrients in plant, especially the concentration of phosphorous, copper and zinc was all increased in the leaf, stem and flower. The experimental results showed application of strain TCT168 products with the best effect in promoting growth of Eustoma in the field and its cut flower quality in vase.