蝴蝶蘭對氮素的吸收、分配及利用
The uptake, partitioning, and utilization of nitrogen in *Phalaenopsis*

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Outline 大綱

- Effects of nitrogen concentrations on growth and flowering of *Phalaenopsis*.
- Effects of nitrogen forms on growth and flowering of *Phalaenopsis*.
- The uptake of nitrogen in *Phalaenopsis*.
- The partitioning of nitrogen in *Phalaenopsis*.
- Conclusion

（因為有外賓，大會希望簡報檔儘量以英文呈現，但口頭會以中文詳細說明，敬請見諒）

表. 不同濃度氮肥處理對臺灣蝴蝶蘭到梗日數、抽梗至花苞可見日數、抽梗至第一朵花開日數，及花序壽命之影響。

Table. Effect of nitrogen concentration on days to spiking, days from spiking to visible bud, days from spiking to first flower anthesis, and longevity of inflorescence in *Phalaenopsis amabilis* during two flowering cycles.

Fertilizer treatment (ppm)			First flowering cycle				Second flowering cycle			
N	P	K	Days to spiking	Days from spiking to VB[z]	Days from spiking to FA[y]	Longevity of inflorescence (days)	Days to spiking	Days from spiking to VB	Days from spiking to FA	Longevity of inflorescence (days)
0	100	300	38.2 a[x]	46.7 a	79.3 a	76.3 a	32.4 b	46.7 a	76.5 a	91.2 a
100	100	300	37.7 a	47.0 a	81.4 a	75.3 a	36.1 ab	47.4 a	74.4 a	80.9 a
200	100	300	37.6 a	47.8 a	79.8 a	71.9 a	36.9 ab	47.9 a	70.7 a	81.2 a
300	100	300	37.8 a	47.2 a	79.8 a	74.6 a	38.7 a	47.5 a	75.2 a	71.6 a

[z] VB: Visible bud.

[y] FA: First flower anthesis

[x] Means followed by a different letter in columns are significantly different at $P \leq 0.05$ by LSD test.

表. 不同濃度氮肥處理對臺灣蝴蝶蘭花梗數、花朵大小、花梗直徑及花朵數之影響。

Table. Effect of nitrogen concentration on number of spikes per plant, flower size, diameter of stalks, number of flowers per plant, and no. of flowers per plant in *Phalaenopsis amabilis* during two flowering cycles.

Fertilizer treatment (ppm)			First flowering cycle				Second flowering cycle			
N	P	K	No. of spikes/ plant	Diameter of stalk (mm)	Flower size (cm)	No. of flowers/ plant	No. of spikes/plant	Diameter of stalk (mm)	Flower size (cm)	No. of flowers/ plant
0	100	300	1.8ab[z]	4.5a	7.0 a	14.4 a	1.2 a	5.2 a	6.8 a	8.4 b
100	100	300	1.9a	4.6a	6.8 a	15.2 a	1.3 a	4.8 a	6.5 b	11.3 a
200	100	300	1.7ab	4.5a	6.5 a	15.3 a	1.3 a	4.8 a	6.0 c	8.2 b
300	100	300	1.7b	4.5a	6.7 a	14.1 a	1.1 a	4.9 a	6.1 c	9.6 a
										b

[z] Means followed by a different letter in columns are significantly different at $P \leq 0.05$ by LSD test.

表. 不同濃度氮肥處理對臺灣蝴蝶蘭總鮮重、總葉面積、新生葉片數之影響。

Table. Effect of nitrogen concentration on total fresh weight, total leaf area, and number of new leaves in *Phalaenopsis amabilis* during two flowering cycles.

Fertilizer treatment (ppm)			First flowering cycle			Second flowering cycle		
N	P	K	Total fresh weight (g)	Total leaf area (cm^2)	No. of new leaves	Total fresh weight (g)	Total leaf area (cm^2)	No. of new leaves
0	100	300	147.9 a[z]	414.1 b	2.05 c	116.7 b	281.0 c	2.7 c
100	100	300	152.6 a	501.9 ab	2.25 bc	126.1 b	421.3 bc	4.1 b
200	100	300	155.6 a	522.4 a	2.49 a	125.7 b	432.6 b	4.7 ab
300	100	300	153.0 a	546.2 a	2.37 ab	182.0 a	627.5 a	5.0 a

[z] Means followed by a different letter in columns are significantly different at $P \leqq 0.05$ by LSD test.

表. 不同濃度氮肥處理對臺灣蝴蝶蘭總乾重、地上部乾重、地下部乾重之影響。

Table. Effect of nitrogen concentration on shoot dry weight, root dry weight, and total dry weight of *Phalaenopsis amabilis* during two flowering cycles.

Fertilizer treatment (ppm)			First flowering cycle			Second flowering cycle		
			Dry weight (g)			Dry weight (g)		
N	P	K	Shoot	Root	Total	Shoot	Root	Total
0	100	300	6.7 a[z]	5.4 a	12.2 a	4.9 b	7.4 a	12.3 b
100	100	300	6.7 a	4.8 a	11.5 a	6.5 ab	6.8 ab	13.2 ab
200	100	300	7.2 a	4.0 a	11.2 a	6.5 ab	5.4 b	11.7 b
300	100	300	7.0 a	7.4 a	14.4 a	7.3 a	7.9 a	15.2 a

[z] Means followed by a different letter in columns are significantly different at $P \leqq 0.05$ by LSD test.

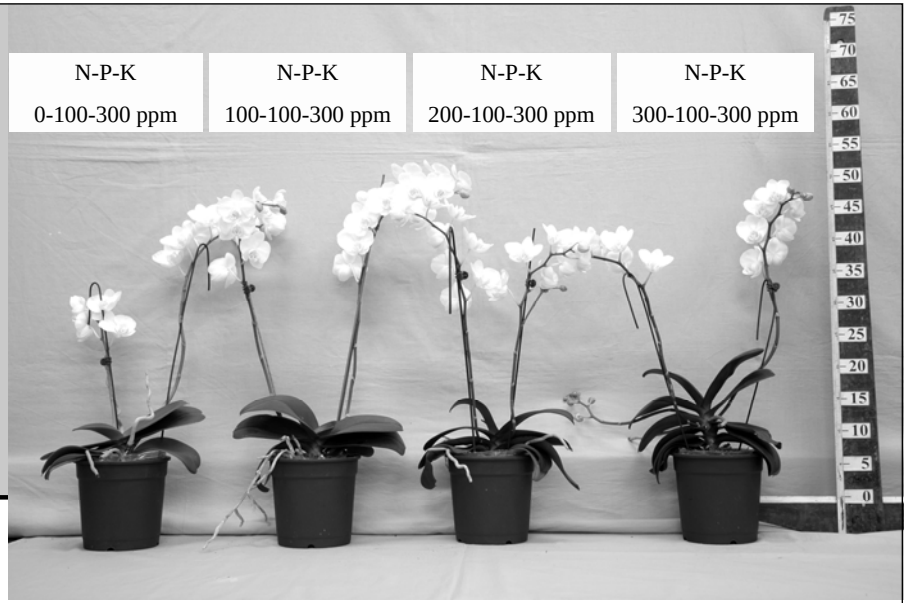

圖. 不同濃度氮肥料處理，對蝴蝶蘭第二開花周期之植株及開花品質之影響。
Fig. Effect of nitrogen applied on plant growth and flower quality in *Phalaenopsis amabilis* in the second flowering cycle.

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表 4. 氮素型態比例對蝴蝶蘭大苗抽梗率、至抽梗日數、至花苞可見日數、至第一朵花開日數之影響(第一及第二開花周期)。

Table 4. Effect of nitrogen form ratio on percentage of spiking, days to spiking, days to visible buds, and days to anthesis in *Phalaenopsis* Sogo Yukidian 'V3' during the first and the second flowering cycles.

$NH_4^+ : NO_3^-$ ratio	The first flowering cycle				The second flowering cycle			
	Percentage of spiking (%)	Days to spiking	Days to visible buds	Days to anthesis	Percentage of spiking (%)	Days to spiking	Days to visible buds	Days to anthesis
0 : 100	52.4	54.5 a[z]	111.1 a	140.4 a	90.5	43.8 a	106.6 a	154.4 a
25 : 75	33.3	44.4 a	106.7 a	135.9 a	95.2	40.3 a	97.3 a	148.6 a
50 : 50	42.9	46.7 a	108.4 a	136.3 a	85.7	43.7 a	100.3 a	145.6 a
75 : 25	28.6	46.3 a	111.7 a	139.7 a	66.7	44.4 a	100.4 a	146.1 a
100 : 0	71.4	40.3 a	104.7 a	133.9 a	9.5	57.5 a	117.5 a	160.5 a

[z]Means separation within the same column by different letter were significantly different at 5% level by LSD test; n=21.

表 5. 氮素型態比例對蝴蝶蘭大苗花序壽命、主幹上花朵數、總花朵數、花梗分支數、花梗直徑、長度及花朵直徑之影響(第一及第二開花周期)。

Table 5. Effect of nitrogen form ratio on inflorescence longevity, number of flowers on the main stalk, number of flowers per plant, number of branches on the stalk, stalk diameter, stalk length and flower diameter in *Phalaenopsis* Sogo Yukidian 'V3' during the first and the second flowering cycles.

$NH_4^+ : NO_3^-$ ratio	The first flowering cycle			The second flowering cycle						
	Inflorescence longevity	Flower diameter (cm)	No. of flowers on the main stalk	First Flower longevity	Inflorescence longevity	No. of flowers on the main stalk	No. of flowers per plant	No. of branches on the stalk	Stalk diameter (cm)	Stalk length (cm)	Flower diameter (cm)
0 : 100	86.2 a[z]	11.6 a	9.0 a	69.2 a	96.4 a	11.4 a	18.5 a	1.5 a	0.77 a	98.4 ab	12.3 a
25 : 75	86.7 a	11.8 a	8.6 a	78.9 a	100.5 a	11.6 a	18.5 a	1.3 ab	0.73 ab	106.8 a	12.2 a
50 : 50	90.6 a	11.5 a	9.1 a	82.8 a	102.6 a	12.1 a	16.2 a	0.8 b	0.71 bc	104.1 a	12.2 a
75 : 25	87.0 a	11.6 a	8.7 a	80.1 a	98.1 a	11.0 a	11.7 b	0.2 b	0.67 c	93.5 bc	12.0 a
100 : 0	86.7 a	11.3 a	9.1 a	70.0 a	80.0 a	9.0 a	9.0 b	0.0 b	0.62 c	75.8 c	11.6 a

[z]Means separation within the same column by different letter were significantly different at 5% level by LSD test; n=21.

Flowering quality decreased when the portion of NH_4^+-N exceeded 50%.

銨態氮比例超過50%處理，開花品質顯著下降

表 6. 氮素型態比例處理前後對蝴蝶蘭大苗鮮重、乾重及地上部與地下部比例之影響(第一及第二開花周期後)。

Table 6. Effect of nitrogen form ratio on the fresh weight, dry weight, and shoot to root ratio in *Phalaenopsis* Sogo Yukidian 'V3' after the first and the second flowering cycles.

$NH_4^+ : NO_3^-$ ratio	Fresh weight before treatment (g)	After the first flowering cycle	After the second flowering cycle							
			Fresh weight (g)				Dry weight (g)			
		Fresh weight after treatment (g)	Shoot	Root	Total	Shoot to root ratio	Shoot	Root	Total	Shoot to root ratio
0 : 100	160.4 a[z]	277.0 ab	197.8 a	107.4 a	305.2 a	1.86 b	13.4 a	14.1 a	27.5 a	0.95 a
25 : 75	160.2 a	301.8 a	222.0 a	105.5 a	327.5 a	2.16 ab	14.2 a	13.9 a	28.1 a	1.03 a
50 : 50	160.2 a	252.9 bc	153.5 b	69.3 b	222.7 b	2.26 ab	10.4 b	10.8 b	21.2 b	0.98 a
75 : 25	160.3 a	232.1 c	133.1 b	57.5 b	190.6 b	2.41 a	7.7 c	7.5 c	15.2 c	1.01 a
100 : 0	160.4 a	116.6 d	64.9 c	48.3 c	113.1 c	1.37 c	3.2 d	6.4 d	9.6 d	0.50 b

[z]Means separation within the same column by different letter were significantly different at 5% level by LSD test; n=21.

Fresh weight and dry weight decreased when the portion of NH_4^+-N exceeded 50%.

銨態氮比例大於50%處理，鮮重與乾重顯著下降

表 7. 氮素型態比例對蝴蝶蘭大苗總葉片數、新生葉片數與落葉數之影響(第一及第二開花周期後)。

Table 7. Effect of nitrogen form ratio on the number of total leaves, newly gorwn leaves, and defoliated leaves in *Phalaenopsis* Sogo Yukidian 'V3' after the first and the second flowering cycles.

$NH_4^+ : NO_3^-$ ratio	No. of leaves						
	Before treatment	After the first flowering cycle			After the second flowering cycle		
	Total	Total	New	Defoliated	Total	New	Defoliated
0 : 100	4.4 b[z]	6.1 ab	3.7 a	2.0 bc	6.3 b	2.9 b	2.7 b
25 : 75	4.4 b	6.5 a	3.7 a	1.6 c	7.1 a	3.0 b	2.4 b
50 : 50	4.3 b	5.7 bc	3.6 a	2.2 b	6.3 b	3.1 b	2.5 b
75 : 25	4.5 ab	5.3 c	4.0 a	3.2 a	6.0 b	3.6 a	2.9 b
100 : 0	4.7 a	4.0 d	2.6 b	3.4 a	3.8 c	3.9 a	4.3 a

[z]Means separation within the same column by different letter were significantly different at 5% level by LSD test; n=21.

No. of defoliated leaves increased as the NH_4^+-N/NO_3^--N ratio increased.

100%銨態氮處理，總葉片數下降，落葉數增加

表 8. 氮素型態比例對蝴蝶蘭大苗第一片與第二片成熟葉長、寬、長寬比與葉面積之影響(第一及第二開花周期後)。

Table 8. Effect of nitrogen form ratio on the length, width, length to width ratio and area of the first and second mature leaves in *Phalaenopsis* Sogo Yukidian 'V3' after the first and the second flowering cycles.

NH_4^+ : NO_3^- ratio	After the first flowering cycle							
	1st mature leaf[z]				2nd mature leaf			
	Length (cm)	Width (cm)	Leaf area[y] (cm^2)	Length to width ratio	Length (cm)	Width (cm)	Leaf area (cm^2)	Length to width ratio
0 : 100	19.5 a[x]	7.3 a	102.5 a	2.69 a	23.2 a	9.0 a	151.4 a	2.58 a
25 : 75	19.1 a	7.1 ab	98.9 a	2.68 a	22.2 ab	8.4 ab	138.0 a	2.64 a
50 : 50	18.6 ab	7.2 a	97.3 ab	2.59 a	23.0 a	8.7 a	145.8 a	2.63 a
75 : 25	17.3 b	6.7 b	84.7 b	2.59 a	20.1 b	8.0 b	117.2 b	2.52 ab
100 : 0	12.4 c	6.1 c	56.1 c	2.01 b	17.1 c	7.0 c	88.9 c	2.40 b

NH_4^+ : NO_3^- ratio	After the second flowering cycle							
	1st mature leaf				2nd mature leaf			
	Length (cm)	Width (cm)	Leaf area (cm^2)	Length to width ratio	Length (cm)	Width (cm)	Leaf area (cm^2)	Length to width ratio
0 : 100	22.8 a	8.1 a	133.0 a	2.85 a	22.3 a	7.5 a	121.6 a	2.95 a
25 : 75	22.7 ab	8.2 a	135.4 a	2.78 a	22.2 a	7.6 a	121.2 a	2.93 a
50 : 50	21.2 b	7.8 ab	119.7 b	2.73 a	21.7 a	7.4 a	116.1 a	2.94 a
75 : 25	17.7 c	7.4 b	96.2 c	2.38 b	19.7 b	7.4 a	105.5 b	2.67 b
100 : 0	15.6 c	7.3 b	84.3 c	2.12 b	15.5 c	6.7 b	76.5 c	2.32 c

[z]The mature leaf that has just fully expanded.

[y]The leaf area was estimated by (leaf length) x (leaf width) x 0.7221.

[x]Means separation within the same column by different letter were significantly different at 5% level by LSD test; n=21.

Leaf area decreased when the portion of NH4+-N exceeded 50%.

銨態氮比例超過50%處理，葉長寬與葉面積顯著下降

表 10. 氮素型態比例對蝴蝶蘭大苗地上部礦物元素濃度之影響(第二開花周期後)。

Table 10. Effect of nitrogen form ratio on the concentration of mineral elements of shoot in *Phalaenopsis* Sogo Yukidian 'V3' after the second flowering cycle.

NH_4^+ : NO_3^- ratio	Concentration								
	N (%)	NH_4^+ (%)	NO_3^- (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe ($\mu g \cdot g^{-1}$)	Mn ($\mu g \cdot g^{-1}$)
0 : 100	1.78 c[z]	1.66 c	0.12 a	0.23 c	2.50 ab	1.56 a	0.35 ab	79 b	441 c
25 : 75	1.89 c	1.76 c	0.13 a	0.26 c	2.31 b	1.19 b	0.33 b	83 b	402 c
50 : 50	1.84 c	1.76 c	0.08 a	0.28 c	2.30 b	1.06 b	0.33 b	68 b	427 c
75 : 25	2.61 b	2.46 b	0.15 a	0.36 b	2.43 ab	1.09 b	0.38 a	126 a	566 b
100 : 0	3.45 a	3.31 a	0.13 a	0.48 a	2.76 a	0.84 c	0.32 b	72 b	786 a

[z]Means separation within the same column by different letter were significantly different at 5% level by LSD test; n=21.

表 11. 氮素型態比例對蝴蝶蘭大苗地下部礦物元素濃度之影響(第二開花周期後)。

Table 11. Effect of nitrogen form ratio on the concentration of mineral elements of root in *Phalaenopsis* Sogo Yukidian 'V3' after the second flowering cycle.

NH_4^+ : NO_3^- ratio	Concentration								
	N (%)	NH_4^+ (%)	NO_3^- (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe ($\mu g \cdot g^{-1}$)	Mn ($\mu g \cdot g^{-1}$)
0 : 100	2.09 b[z]	1.97 b	0.12 a	0.43 a	0.66 b	0.55 a	0.26 a	95 bc	55 ab
25 : 75	2.13 b	1.90 b	0.23 a	0.36 b	0.75 b	0.47 ab	0.28 a	85 c	43 b
50 : 50	2.26 b	2.13 b	0.13 a	0.35 b	1.02 a	0.49 ab	0.28 a	95 bc	65 ab
75 : 25	3.47 a	3.22 a	0.25 a	0.32 b	0.77 b	0.44 bc	0.18 b	143 a	63 ab
100 : 0	3.02 a	2.89 a	0.14 a	0.33 b	0.80 b	0.37 c	0.15 b	118 ab	81 a

[z]Means separation within the same column by different letter were significantly different at 5% level by LSD test; n=21.

- Best growth and flowering of *Phalaenopsis* Sogo Yukidian 'V3' was obtained when NH_4^+ : NO_3^- = 25 : 75.

當NH_4^+ : NO_3^- = 25 : 75 時，有最高的抽梗率、鮮重及葉片數

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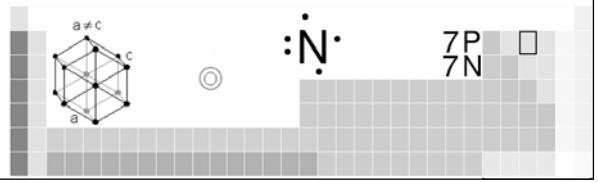
Stable isotope ^{15}N 穩定性氮同位素^{15}N

- 原子組成：質子、中子、電子
- 氮原子有14個質子及中子，表示為^{14}N
- ^{14}N and ^{15}N are two stable nitrogen isotopes.
  ^{14}N與^{15}N為氮的兩種天然穩定同位素
- ^{15}N has one more neutron than ^{14}N in its nucleus.
  ^{15}N為比^{14}N多一個中子的氮
- Atmospheric N has approximately 0.366% ^{15}N abundance.
  大氣中^{14}N佔了99.634 %，^{15}N則佔0.366 %
- 同位素之間
  性質相同



How ^{15}N can be used in nitrogen study?
利用氮同位素可以…

- To trace the uptake and partitioning of nitrogen in *Phalaenopsis*
  瞭解蝴蝶蘭對氮素之吸收及運移情形
  - 施用^{15}N
  - 等一段時間後分析不同部位
  - 哪個部位^{15}N多就表示氮素被優先運移至該處
- To understand the sink-source relationship of nitrogen in *Phalaenopsis*
  瞭解蝴蝶蘭對氮素之吸收及瞭解各器官於不同時期之功能與角色
  - 施用^{15}N
  - 一段時間後分析A部位^{15}N含量
  - 再隔一段時間後分析A部位及B部位(B為新生長的器官)^{15}N含量，若A部位減少B部位增加，表示氮由A運往B

The uptake of nitrogen

- Both leaves and roots are capable of taking up nitrogen. Which one works more efficiently?
  根葉何者對肥料的吸收效率較好？
- Where is nitrogen trasnlocated after being taken up?
  氮被吸收後被運往何處？

Experimental design 試驗設計

- ^{15}N was fed to:
  分別在蝴蝶蘭不同部位給予氮同位素:
  1. Upper surface of leaves 葉片上表皮
  2. Lower surface of leaves 葉片下表皮
  3. Newly grown roots 新根
  4. Old roots 老根

- Organs harvested and ^{15}N determined on Week 8
  八週後取樣分析不同部位有多少氮同位素

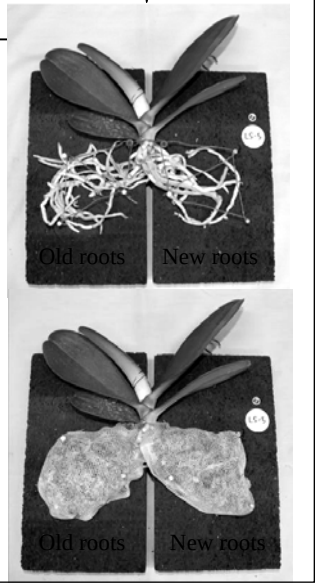


表 56. 施用氮同位素於蝴蝶蘭葉片上下表皮或新舊根部對其各部位氮同位素濃度(扣除背景值)之影響(處理後八週)。

Table 56. The effect of isotopic nitrogen treatment on upper surface, lower surface of leave, new roots, or old roots on ^{15}N concentration (atom % excess) of newly gorwn leaves, mature leaves, new roots, old roots, and aerial roots in *Phalaenopsis* Sogo Yukidian 'V3'; n=6. (Eight weeks after treatment)

^{15}N Treatment	^{15}N concentration (atom % excess)[z]				
	Newly grown leaves	Mature leaves	New roots	Old roots	Aerial roots
Leaves, upper surface	0.023 c C[y]	0.041 a A	0.018 c D	0.011 c E	0.030 c B
Leaves, lower surface	0.016 c B	0.031 b A	0.014 c B	0.008 c C	0.027 c A
New roots	0.086 a B	0.030 bc C	0.139 a A	0.045 b C	0.094 a B
Old roots	0.062 b B	0.025 c C	0.039 b C	0.158 a A	0.064 b B

[z]The atom percent ^{15}N excess (atom % excess) were obtained by subtracting natural abundance of ^{15}N (0.366 atom %) from the results of the ^{15}N analyses.

[y]Means separation within the same columns (lower case) and rows (upper case) by different letters were significantly different at 5% level by LSD test.

表 58. 施用氮同位素於蝴蝶蘭葉片上下表皮或新舊根部對其各部位氮同位素含量(扣除背景值)之影響(處理後八週)。

Table 58. The effect of isotopic nitrogen treatment on upper surface, lower surface of leave, new roots, or old roots on ^{15}N content excess of newly gorwn leaves, mature leaves, new roots, old roots, and aerial roots in *Phalaenopsis* Sogo Yukidian 'V3'; n=6. (Eight weeks after treatment)

^{15}N Treatment	^{15}N content excess (μg)[z]					
	Newly grown leaves	Mature leaves	New roots	Old roots	Aerial roots	Total
Leaves, upper surface	6.5 b B[y]	17.8 a A	3.2 c C	1.3 c D	3.0 b CD	31.8 c
Leaves, lower surface	4.2 b B	13.1 b A	3.2 c BC	0.7 c D	2.3 b CD	23.6 c
New roots	22.6 a B	13.6 b C	27.3 a A	5.0 b D	8.9 a D	77.3 a
Old roots	18.7 a A	11.4 b BC	6.6 b CD	12.3 a B	7.4 a D	56.3 b

[z] ^{15}N content excess = ^{15}N concentration (atom % excess) * nitrogen concentration * dry weight.

[y]Means separation within the same columns (lower case) and rows (upper case) by different letters were significantly different at 5% level by LSD test.

Results: The uptake of nitrogen

- Both roots and leaves are capable on nitrogen absorption.
  蝴蝶蘭之葉面與根部均具有吸收氮素之功能。
- The uptake efficiency: New roots > old roots > leaves
  對氮素之吸收效率：新根＞老根＞葉片
- There was no difference on nitrogen uptake efficiency between upper and lower leaf surfaces.
  葉片之上下表皮對於氮素之吸收無顯著差異
- Newly grown leaves and roots are major sinks for nitrogen.
  新生葉片與氣生根為強積儲

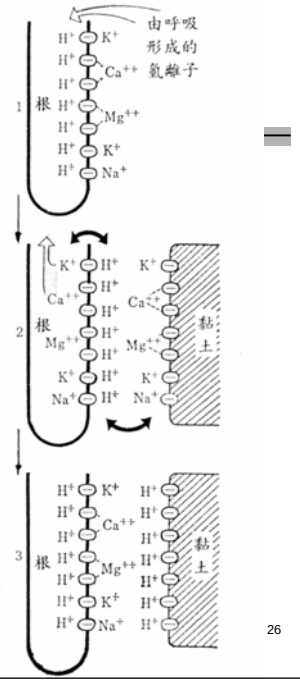
Foliar application of mineral nutrients
葉面施肥

- The stomatal density in lower epidermis is 2X higher than that of upper epidermis in *Phalaenopsis* leaves.
  蝴蝶蘭下表皮氣孔為上表皮兩倍
  - Our results indicated that there was no difference on nitrogen uptake efficiency between upper and lower leaf epidermis.
    但，上下表皮對於^{15}N吸收無顯著差異
  - → It is unlikely that direct penetration of solutes through open stomata plays an important role.
    營養不是從氣孔進入葉片的
- Leaf surface is covered by cuticle layer.
  葉片上下表皮都有一層角質層
  - → It is more likely that the solutes are taken up via cuticular pores. 角質裂孔為營養進入主要途徑

Uptake of nutrients
養分的吸收

- The roots are the main sites of mineral nutrition uptake; the surface of leaves can also take up some nutrients.

  根部為主，葉面亦能吸收部分養分



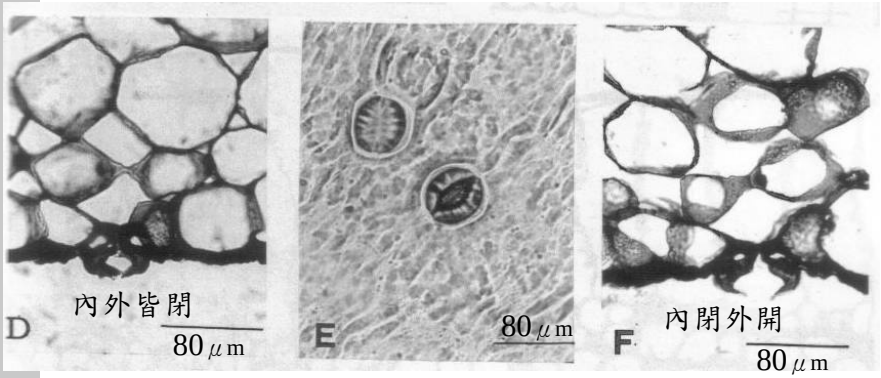
根的養分交換吸收

Foliar feeding葉面施肥

Table 5.18. Factors that determines the efficacy of foliar feeding.
影響葉面施肥效率的因子

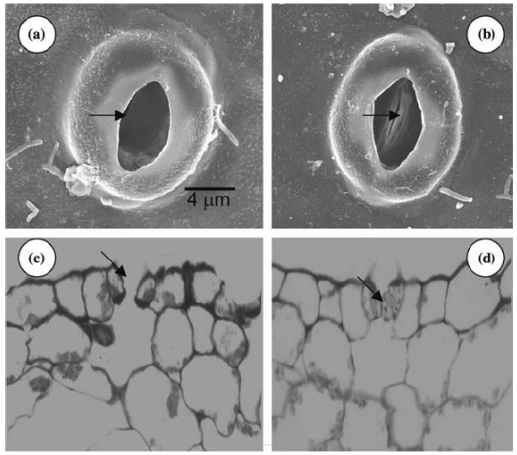
Plant	Environment	Spray solution
Cuticular wax	Temperature	Concentration
Epicuticular wax	Light	Application rate and technique
Leaf age	Photoperiod	Wetting agent
Stomata	Wind	pH
Guard cells	Humidity	Polarity
Trichomes, leaf hairs	Drought	Hygroscopicity
Leaf turgor	Time of the day	Compounds used
Surface moisture	Osmotic potential of the root medium	Sticking property
Cultivar	Nutrient stress	Nutrient ratio
Growth stage		Carriers, penetrants

Adapted from Alexander (1986).



Cuticular ridges and stomata in *Paph. micranthum*.
拖鞋蘭的氣孔形態。

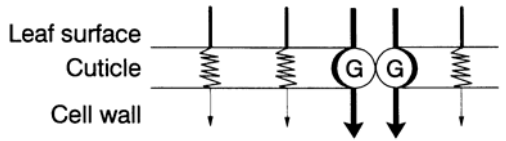
Cuticular ridges 角質脊



朵麗蝶蘭之下表皮

Figure 3. Scanning electron microscopes (a, b) and longitudinal sections (c, d) of abaxial leaf surface of *Doritaenopsis* plants after 4 months of acclimatization in the greenhouse under different levels of PPFDs showing open stomata (a, c) at 150–200 μmol m^{-2} s^{-1} and closed stomata (b, d) at 400–500 μmol m^{-2} s^{-1}.

Some misunderstandings regarding foliar application
葉面施肥的迷思



G: guard cell

- Cuticular pore offers the permeation of low-molecular-weight solutes (e.g. sugars, urea, mineral elements).
- These small pores are lined with fixed negative charges. Thus uptake of cations by leaves is thus faster than that of anions.
- Cuticular pore density is higher in the cell walls between guard cells and subsidiary cells; this explain the commonly observed positive correction between number or distribution of stomata and the intensity of mineral nutrition uptake.
- It is unlikely that direct penetration of solutes from the leaf surface through open stomata into the leaf tissue plays an important role.

Where is nitrogen partitioned after being taken up?

氮被根部吸收後，去哪裡呢？

Experimental design 試驗設計

- Methods:
  ^{15}Nitrogen was fed from the bottom of the pot. Eight weeks later, individual leaves are harvested and ^{15}N determined.
  將含^{15}N的肥料由底部灌溉，正常管理8週後，分別測植株不同葉片含^{15}N多寡。含^{15}N較多者表示根部吸收的營養會優先運移至該處。

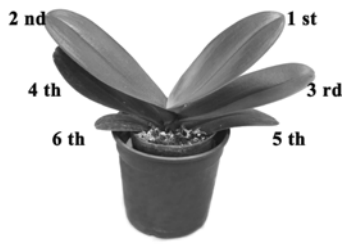


表 19. 蝴蝶蘭不同部位葉片之乾重、氮素濃度及含量、氮同位素濃度及含量。

Table 19. The dry weight, N concentration and content, ^{15}N concentration and content of different parts of leaves in *Phalaenopsis* Sogo Yukidian 'V3'; n=6.

	Dry Weight (g)	N concentration (%)	N content (mg)	^{15}N concentration (atom %)	^{15}N content (μg)
1st leaf [z]	0.96 c[y]	2.31 a	22.16 b	1.448 a	321 a
2nd leaf	1.54 a	1.74 b	26.71 a	1.169 b	313 a
3rd leaf	1.27 b	1.55 c	19.68 c	0.721 c	142 b
4th leaf	0.97 c	1.41 d	13.69 d	0.612 d	84 c
5th leaf	0.64 d	1.17 e	7.49 e	0.725 c	55 cd
6th leaf	0.35 e	1.16 e	4.00 f	0.705 c	28 d

[z]The first leaf means the youngest leaf, and the sixth leaf means the oldest (lowest) leaf of the plant.

[y]Means separation within the same column by different letters were significantly different at 5% level by LSD test; n=6.

- The sink strength of leaves decreased as the leaf age increased.
  吸收的氮會優先運送到新葉
- ^{15}Nitrogen can be used as a tracer for nitrogen partitioning studies.
  ^{15}N可以做為追蹤氮素去向的工具

What are the nitrogen sources for stalk development? Stored N or fertilizer N?

開花所需的營養從哪來？

Experimental design 試驗設計

- By feeding plants with ^{15}N at different developing stages and then determine the ^{15}N abundance in stalk, we can realize the N sources for stalk development.

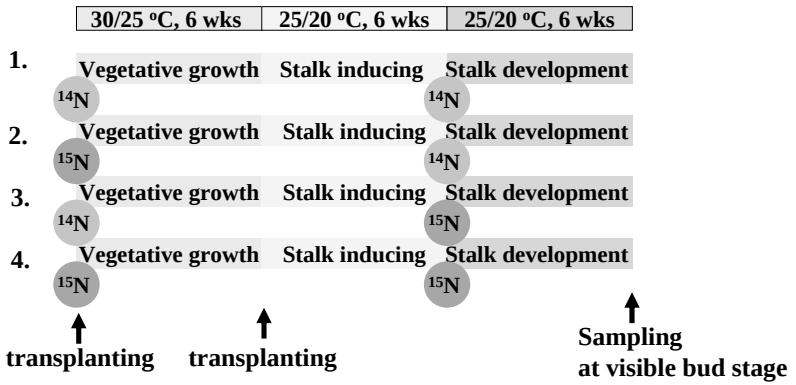


表 24. 於營養生長期或生殖生長期施用氮同位素肥料對蝴蝶蘭各部位氮同位素濃度(扣除背景值)之影響。

Table 24. Effect of application timing of ^{15}N fertilizer on ^{15}N concentration (atom % excess) of newly gorwn leaves, mature leaves, roots, and stalks in *Phalaenopsis* Sogo Yukidian 'V3'; n=6.

Stage of ^{15}N application	^{15}N concentration (atom % excess)[z]			
	Newly grown leaves	Mature leaves	Roots	Stalks
None	0.001 d A[y]	0.001 d A	0.000 d A	0.001 c A
Vegetative	0.578 b A	0.225 b C	0.417 c B	0.408 b B
Reproductive	0.326 c B	0.110 c B	0.767 b A	0.668 b A
Veg. and rep.	0.936 a B	0.302 a C	1.079 a AB	1.122 a A

[z]The atom percent ^{15}N excess (atom % excess) were obtained by subtracting natural abundance of ^{15}N (0.366 atom %) from the results of the ^{15}N analyses.

[y]Means separation within the same columns (lower case) and rows (upper case) by different letters were significantly different at 5% level by LSD test.

	Vegetative, 6 wks	Low temp., 6 wks	Reproductive, 6 wks
1.	^{14}N		^{14}N
2.	^{15}N		^{14}N
3.	^{14}N		^{15}N
4.	^{15}N		^{15}N

2-1, 4-3 → from Veg. → Stored
3-1, 4-2 → from Rep.→Absorbed

For stalks at visible bud stage

Table 28. The nitrogen source of newly grown leaves, mature leaves, roots, and stalks in *Phalaenopsis* Sogo Yukidian 'V3'. (Calculated from the ^{15}N content of organs by different application timing of ^{15}N fertilizer.)

Source of nitrogen **For stalks**	Calculated formula	^{15}N content (μg) Newly grown leaves	Mature leaves	Roots	Stalks	Total
Stored **from Veg.**	Veg.-none	435 a A[z]	128 a B	345 ab A	73 bc B	982 a
	Both-rep.	367 ab A	136 a BC	243 b AB	51 c C	797 a
Newly absorbed **from Rep.**	Rep.-none	257 bc B	62 b B	569 a A	162 a B	1050 a
	Both				140 ab B	865 a

62 μg

151 μg

Stored N 62/(62+151) = 29%

Absorbed N 151/(62+151) = 71%

[z]Means separation in column (lowercase) and row (uppercase) by different letters were significantly diff

- Growing young leaf is the major sink during vegetative stage and stalk during reproductive phase.
- In a nutrient abundant environment, the nitrogen demand of stalks from spiking to bud visible stage was provided 29% from the nitrogen previously stored, and 71% from the recent fertilizer applications.
- The stored N may come from mature leaves and/or roots.
- Fertilization practices before stalk emergency and during inflorescence development are both important.

Conclusion I 結論

- The nutrition status of *Phalaenopsis* plants is of great importance for future growth and flowering; it is difficult to make a right judge visually. Only get plant supplies from good growers, and build up your own reputation.
  蝴蝶蘭苗期的營養管理將影響日後的開花品質，請留意取得健康種苗，也留意建立自己的信譽。
- Nitrogen concentration at 200 ppm is recommended for *Phalaenopsis* cultivation.
  本研究給予蝴蝶蘭 200 ppm 的氮肥濃度，有最佳之生長發育及花朵品質。

Conclusion II 結論

- High concentration of NH_4^+-N causes toxicity; The portion of NH_4^+-N should not exceed 25%.
  過高之銨態氮導致毒害，肥料中之銨態氮不宜高於 25%.
- Growing young leaf is the major sink during vegetative stage and stalk during reproductive phase.
  在苗期，新生葉是最強的積貯；在生殖生長期，花梗則是最強的積貯。所謂的積貯，是養分優先運往的部位。

Conclusion III 結論

- Leaves have a lower nitrogen uptake efficiency compared with that of roots. The important role of roots on nitrogen uptake should not be ignored.
  對營養吸收，根部比葉面的效果好。**不能只注重葉面施肥而忽略根域肥分。**
- Mature leaves and roots have functions of nitrogen storage; the nitrogen demands of stalks are supplied by both stored-N and fertilizer-N. Fertilization practices before stalk emergency and during inflorescence development are both important.
  蝴蝶蘭具貯藏養分的能力，施肥的影響是長遠的。花梗發育時有七成營養來自當時根部吸收的營養，三成來自先前貯存的養分。因此開花前後均必須持續地供應蝴蝶蘭開花所需營養。

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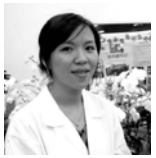

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The end – 謝謝！ 敬請指教！！


台大園藝系花卉館

Thank you for your attention.