葉面噴施養液對椪柑葉片性狀及果實品質之影響[1]

曾宥綻[2]、郭雅紋[2]、陳鴻堂[2]

摘　要

以4種養液葉面噴施於椪柑，分別為(1) 10 mM硝酸鉀+15 mM硫酸鈣+10 mM磷酸一鉀、(2) 15 mM硫酸鈣+60 mM磷酸一鉀、(3) 15 mM硫酸鈣及(4) 60 mM磷酸一鉀，並設對照組噴施自來水，探討其對椪柑果實品質及風災抗性之影響。豐原試驗區葉片氮、磷及鉀含量落於適宜養分值內，且葉面噴施15 mM硫酸鈣+60 mM磷酸一鉀或60 mM磷酸一鉀可增加葉片磷含量，噴施15 mM硫酸鈣或60 mM磷酸一鉀可顯著提升葉片鈣含量。果實糖酸比以施用15 mM硫酸鈣或60 mM磷酸一鉀有顯著提升，且葉面噴施4種養液皆可降低蘇迪勒颱風後之椪柑落果率。東勢試驗區葉片氮含量低於養分適宜值，噴施60 mM磷酸一鉀可顯著提升葉片磷與鉀含量，然會降低椪柑果長、果肉重、酸度及榨汁率，但糖酸比顯著提升，另葉面噴施15 mM硫酸鈣與60 mM磷酸一鉀亦降低果實榨汁率，此兩處理之葉片氮鉀比皆降至1.3，顯示植體低氮高鉀會導致椪柑果實榨汁率下降。試驗結果顯示，椪柑植株氮含量充足搭配葉面噴施磷酸一鉀，可維持果實品質並提高其糖酸比，且葉面施肥管理具有降低風災損害之應用潛力。

關鍵詞：椪柑、葉面施肥、果實品質

前　言

臺灣地處於亞熱帶與熱帶交會地區，四面環海，屬於高溫多濕的海島型氣候，農作物生產易受氣候多變及颱風、豪雨等影響；例如颱風對農作物經常造成災害而導致重大的損失，此類天然災害對園藝作物之生產影響甚劇[2,3]。鉀離子為植物所需必要養分離子，植物缺乏鉀離子將增加其呼吸率及蒸散率並減少光合作用，將導致光合產物的減少，如澱粉及纖維素等，因此植物缺鉀會影響其莖幹強度[9]。鉀離子於植物中參與厚壁細胞之木質化，因此可強化植株莖桿強度並減少其倒伏的發生[6]。鉀離子的補充應具有增強作物抵抗物理傷害之效果。鈣於葉片中可與果膠酸結合而形成果膠酸鈣，且為細胞壁中膠層之組成分[15]，因此，鈣離子可提高植物細胞壁的強度，進而增強細胞對物理傷害的抵抗力，故葉施鈣肥具有提高葉片物理傷害之抗性的潛力。前人研究指出葉面施肥可應用於提高柑橘果實產量及品質，如Boman (2001)之報告指出葉面噴施硝酸鉀或磷酸一鉀可增加晚崙西亞橙果粒數、果實大小及總可溶性固形物[5]；EI-Tanany等人(2011)指出葉面噴施鉀、鈣及鎂可增加臍橙果實鮮重、果汁率、

[1] 行政院農業委員會臺中區農業改良場研究報告第 0912 號。
[2] 行政院農業委員會臺中區農業改良場助理研究員。

總可溶性固形物及產量[7]。本研究以葉面噴施不同氮、磷、鉀及鈣養液，以瞭解是否可提高椪柑對風災物理傷害之抗性，及對椪柑品質之影響，並作為日後風災前椪柑葉面施肥營養管理之參考。

材料與方法

試區設置及試驗處理

本研究以5種處理進行椪柑葉面施肥，包括(1)控制組：自來水，(2)葉施10 mM硝酸鉀+15 mM硫酸鈣+10 mM磷酸一鉀，(3)葉施15 mM硫酸鈣+60 mM磷酸一鉀，(4)葉施15 mM硫酸鈣及(5)葉施60 mM磷酸一鉀。

試驗園區設置於臺中市東勢與豐原椪柑產區，試驗區採完全逢機區集，5處理，3重複，每處理重複2株果樹。於當年4月及7月每7~10天葉施養液，每株噴1.5公升，連續施用3次，共施用6次。椪柑養液施用時期為2015年4月22日、4月29日、5月7日、7月7日、7月15日及7月21日。

土壤分析

土壤樣品先經風乾處理，經2 mm篩網過篩後分別測定土壤化學性質，土壤pH以水土比1:1；電導度以水土比1:1，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(pH 7.0)土、溶液比1:10抽出[11,12]，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。土壤以Bray no.1方法抽取[14]，並用感應耦合電漿光譜分析儀測土壤有效性磷。土壤微量要素以0.1 N鹽酸萃取[1]，並以感應耦合電漿光譜分析儀測定。

植體分析

於8月份採非結果枝春梢頂端往下第3葉，並分析葉片之氮、磷、鉀、鈣、鎂、銅、錳、鋅、鐵及硼含量。植體以濃硫酸及雙氧水消化分解[13]，氮用微量擴散法測定[10]，磷用比色法定量[14]，鉀用火焰光度計測定(Sherwood flam photometer 410)，鈣及鎂則用原子吸收光譜儀(Hitachi Polarized Zeeman Atomic absorption spectrophotometer Z-5000)分析。微量要素銅、錳、鋅及鐵則以1 N鹽酸抽出[18]，並以原子吸收光譜儀(Hitachi Polarized Zeeman Atomic absorption spectrophotometer Z-5000)分析。

園藝性狀調查

處理前，每一植株之東、南、西和北面擇生長勢相同枝條進行標定，葉面施肥後調查同一植株東、南、西、北四面之枝梢葉片長、寬及厚。果實採收期每株果樹採6顆果實，進行果重、果皮重、果皮厚、果肉重、榨汁率、糖度、酸度及養分含量並進行果粒數調查。蘇迪勒颱風後於8月10日調查標定枝條之葉片破損率、全株果粒數與落果數。

統計分析

以Least Significance Difference (LSD)法進行，相同字母代表無顯著差異(p=0.05)。

結果與討論

試驗前土壤肥力分析

兩試驗區土壤偏強酸性，東勢試驗區土壤有機質含量較低，兩試驗區之Bray-1磷含量高，且交換性鈣與鎂含量低(表一及表二)。

表一、豐原試驗區試驗前土壤肥力
Table 1. Soil fertility in Fengyuan District

Treatment	pH 1:1	EC 1:1 dS/m	OM g/kg	Bray-1P	Exchangeable K	Exchangeable Ca	Exchangeable Mg	Cu	Mn	Zn	Fe
				mg/K							
Topsoil	4.4	0.30	32	624	289	523	48	5.0	13.5	8.5	64
Subsoil	4.3	0.25	21	591	177	405	41	3.5	8.5	6.0	56

表二、東勢試驗區試驗前土壤肥力
Table 2. Soil fertility in Dongshi District

Treatment	pH 1:1	EC 1:1 dS/m	OM g/kg	Bray-1P	Exchangeable K	Exchangeable Ca	Exchangeable Mg	Cu	Mn	Zn	Fe
				mg/K							
Topsoil	4.8	0.51	22	397	239	489	90	1.7	37	7.3	188
Subsoil	4.6	0.36	14	247	170	388	67	1.3	26	3.3	170

椪柑葉片性狀調查及風災後葉片破損率

豐原椪柑試驗結果顯示(表三)，葉片長、寬及厚度於各處理間無顯著差異，經蘇迪勒颱風後，其葉片破損率以噴施60 mM磷酸一鉀有顯著降低，其他處理與對照組無顯著差異，葉面噴施4種養液處理皆有助於減少颱風所導致的落果率。東勢區椪柑試驗結果如表四所示，葉片長及寬度以施用10 mM硝酸鉀+15 mM硫酸鈣+ 10 mM磷酸一鉀有顯著增加，葉片厚度於各處理間無顯著差異，因此試驗區地勢關係，受颱風影響不顯著，於葉片破損及落果率皆不嚴重，數據無法顯示颱風對果樹之影響。颱風季節防颱要點應為減少落果發生，經豐原區之試驗結果，顯示葉面噴施含鉀及鈣之養液有減少落果發生的潛力。

表三、豐原椪柑葉面噴施養液後之葉片性狀

Table 3. The leaf characteristics of Ponkan after foliar fertilization in Fengyuan experimental orchard

Treatment	Leaf length mm	Leaf width mm	Leaf thickness mm	Leaf breakdown rate[1] %	Fruit drop rate %
Water	53a[2]	25a	0.26a	6.6a	27.0a
10 mM KNO_3+15 mM $CaSO_4$+ 10 mM KH_2PO_4	56a	26a	0.26a	7.9a	7.7b
15 mM $CaSO_4$+ 60 mM KH_2PO_4	54a	26a	0.26a	3.9ab	14.0b
15 mM $CaSO_4$	57a	26a	0.26a	4.5ab	8.6b
60 mM KH_2PO_4	55a	28a	0.27a	0.8b	13.0b

[1] Leaf breakdown rate, % after typhoon Soudelor.

[2] Significant in comparison with control at P = 0.05 (LSD test).

表四、東勢椪柑葉面噴施養液後之葉片性狀

Table 4. The leaf characteristics of Ponkan after foliar fertilization in Dongshi experimental orchard

Treatment	Leaf length mm	Leaf width mm	Leaf thickness mm	Leaf breakdown rate [1] %	Fruit drop rate %
Water	53b[2]	26b	0.25a	0.8	0.7
10mM KNO_3+15 mM $CaSO_4$+ 10 mM KH_2PO_4	59a	29a	0.26a	0	0.2
15 mM $CaSO_4$+ 60 mM KH_2PO_4	53b	26b	0.26a	0	0.2
15 mM $CaSO_4$	56ab	27ab	0.25a	0	0.1
60 mM KH_2PO_4	53b	26b	0.26a	0.2	0.2

[1] Leaf breakdown rate, % after typhoon Soudelor.

[2] Significant in comparison with control at P = 0.05 (LSD test).

椪柑葉片養分分析

豐原試驗區柑橘葉片磷含量以施用15 mM硫酸鈣+60 mM磷酸一鉀或60 mM磷酸一鉀呈顯著增加，葉片鈣含量則以施用15 mM硫酸鈣或60 mM磷酸一鉀有顯著增加，葉片鎂及銅含量以施用15 mM硫酸鈣+60 mM磷酸一鉀顯著降低，其他葉片養分於各處理間無顯著差異(表五)。東勢試驗區椪柑葉片磷含量以施用15 mM硫酸鈣+60 mM磷酸一鉀或60 mM磷酸一鉀呈增加趨勢，施用60 mM磷酸一鉀可顯著增加葉片鉀含量，降低葉片錳含量(表六)。結果顯示，葉面噴施養液可提高葉片中該噴施養液之要素養分含量。葉片養分含量與養分適宜值比較，豐原試驗區葉片鐵含量較適宜值低，而東勢試驗區葉片氮及銅含量低於適宜值，顯示東勢試驗區之樹體氮含量不足。

表五、豐原試驗區椪柑葉面施用不同養液後之葉片養分含量

Table 5. The elemental nutrients of Ponkan leaf after applying different foliar fertilizer in Fengyuan District

Treatment[1]	N	P	K	Ca	Mg	Cu	Mn	Zn	Fe
	%					mg/kg			
1	2.3a[2]	0.12b	0.97a	2.3c	0.24a	4.0ab	151a	38a	38a
2	2.3a	0.13ab	1.03a	2.3c	0.23ab	5.0a	155a	35a	35a
3	2.5a	0.14a	0.95a	2.4bc	0.21b	3.7b	151a	29a	29a
4	2.2a	0.13ab	1.06a	2.9ab	0.25a	4.3ab	170a	31a	31a
5	2.5a	0.14a	1.17a	3.1a	0.24a	5.0a	146a	33a	33a
Reference 1[3]	2.3-2.9	0.09-0.15	1.2-1.7	2.5-5.0	0.30-0.45	5-10	20-75	25-80	40-60
Reference 2[4]	3.0-3.4	0.15-0.25	0.9-1.1	-	0.17-0.44	-	-	-	-

[1] 1. control, 2. 10 mM KNO_3+15 mM $CaSO_4$+ 10 mM KH_2PO_4, 3. 15 mM $CaSO_4$+ 60 mM KH_2PO_4, 4. 15 mM $CaSO_4$, 5. 60 mM KH_2PO_4.

[2] Significant in comparison with control at P = 0.05 (LSD test).

[3] reference from 嚴，1972.

[4] reference from Uchida, 2000.

表六、東勢試驗區椪柑葉面施用不同養液後之葉片養分含量

Table 6. The elemental nutrients of Ponkan leaf after applying different foliar fertilizer in Dongshi District

Treatment[1]	N	P	K	Ca	Mg	Cu	Mn	Zn	Fe
	%					mg/kg			
1	1.76a[2]	0.16ab	1.18b	2.6a	0.29a	2.3a	271a	56a	81a
2	1.69a	0.16b	1.20b	2.6a	0.24a	2.0a	259ab	53a	76a
3	1.70a	0.18a	1.33ab	2.6a	0.28a	2.0a	238ab	53a	73a
4	1.79a	0.16b	1.26b	2.6a	0.25a	2.3a	234ab	50a	68a
5	1.87a	0.18a	1.49a	2.5a	0.28a	2.3a	221b	48a	74a
Reference 1[3]	2.3-2.9	0.09-0.15	1.2-1.7	2.5-5.0	0.30-0.45	5-10	20-75	25-80	40-60
Reference 2[4]	3.0-3.4	0.15-0.25	0.9-1.1	-	0.17-0.44	-	-	-	-

[1] 1. control, 2. 10 mM KNO_3+15 mM $CaSO_4$+ 10 mM KH_2PO_4, 3. 15 mM $CaSO_4$+ 60 mM KH_2PO_4, 4. 15 mM $CaSO_4$, 5. 60 mM KH_2PO_4

[2] Significant in comparison with control at P = 0.05 (LSD test).

[3] reference from 嚴，1972

[4] reference from Uchida, 2000

椪柑果實品質調查

豐原試驗區椪柑果實酸度以施用10 mM硝酸鉀+15 mM硫酸鈣+10 mM磷酸一鉀最高，噴施其他3種養液處理，果實酸度呈降低趨勢，其中以葉面噴施15 mM硫酸鈣或60 mM磷酸一鉀可顯著增加糖酸比，提高柑橘甜味。果實外觀性狀於各養液處理間無顯著差異(表七)。

東勢試驗區椪柑經葉面噴施60 mM磷酸一鉀其果長、果肉重、榨汁率及酸度較對照組低，而糖酸比則較對照組為高，另葉面噴施15 mM硫酸鈣+60 mM磷酸一鉀其果實榨汁率較對照組低(表八)。豐原試驗區果實大小及果肉重未因噴施60 mM磷酸一鉀較對照組低，顯示不同土壤營養管理將導致葉面噴施養液效果的差異，經比較此兩試驗區之葉片氮含量(表五、表六)，顯示東勢試驗區葉片氮含量不足，且於缺氮情形下，葉面噴施磷酸一鉀將顯著影響葉片氮鉀比，如豐原試驗區對照組葉片氮鉀比為2.37，葉面噴施15 mM硫酸鈣+60 mM磷酸一鉀其氮鉀比2.63，葉面噴施磷酸一鉀其氮鉀比為2.14；東勢試驗區對照組葉片氮鉀比為1.49，葉面噴施15 mM硫酸鈣+60 mM磷酸一鉀其氮鉀比降為1.28，葉面噴施磷酸一鉀其氮鉀比降為1.26，結果顯示，柑橘樹體氮含量不足情況下，葉面噴施磷酸一鉀，將導致果肉重量及榨汁率降低，然而由兩試驗區之結果可確認葉面噴施60 mM磷酸一鉀可降低果實酸度，提升果實甜度。另比較東勢試驗區葉片氮鉀比與果實榨汁率，推測葉片氮鉀比降低至1.3即可能發生果實榨汁率下降情形。前人研究亦曾以氯化鉀、硫酸鉀、硝酸鉀與磷酸一鉀進行柑橘液態施肥並探討對果實品質之影響，結果顯示施用磷酸一鉀較其他3種鉀源，可增加果實糖酸比[16]，此與本研究以葉面噴施磷酸一鉀而提高果實糖酸比之結果相似。另前人研究提及柑橘吸收過量鉀肥，有導致果實榨汁率下降的趨勢[8]，此結果與本試驗發現豐原試驗區果實榨汁率較東勢試驗區高，且葉片氮鉀比降低至1.3則榨汁率下降相似。此兩試驗區之柑橘果粒數不因葉面施用養液而有顯著差異。

表七、豐原椪柑果實品質調查

Table 7. The fruit characteristics of Ponkan after foliar fertilizations in Fengyuan experimental orchard

Treatment[1]	Fruit weight g	Fruit length mm	Fruit width mm	Peel thickness mm	Peel weight g	Pulp weight g	Juice content %	TSS degree Brix	Acid %	TSS/Acid	Fruit number plant
1	252.2a[2]	73.9a	79.5a	3.6a	64.7a	187.5a	67.0a	9.4a	0.53ab	17.9bc	233a
2	251.8a	75.5a	78.9a	3.7a	66.3a	185.5a	70.1a	9.6a	0.57a	17.1c	273a
3	246.9a	73.0a	77.3a	3.6a	60.1a	186.8a	68.6a	9.5a	0.50b	19.2ab	256a
4	239.7a	73.3a	77.9a	3.6a	59.8a	179.9a	69.9a	9.5a	0.48b	20.1a	285a
5	260.3a	75.0a	79.4a	3.7a	65.0a	195.3a	67.6a	9.5a	0.48b	20.2a	225a

[1] 1. control, 2. 10 mM KNO_3+15 mM $CaSO_4$+ 10 mM KH_2PO_4 , 3. 15 mM $CaSO_4$+ 60 mM KH_2PO_4 , 4. 15 mM $CaSO_4$, 5. 60 mM KH_2PO_4

[2] Significant in comparison with control at P = 0.05 (LSD test).

表八、東勢椪柑果實品質調查

Table 8. The fruit characteristics of Ponkan after foliar fertilizations in Dongshi experimental orchard

Treatment[1]	Fruit weight g	Fruit length mm	Fruit width mm	Peel thickness mm	Peel weight g	Pulp weight g	Juice content %	TSS degree Brix	Acid %	TSS/Acid	Fruit number plant
1	236.1ab[2]	75.3a	77.0ab	3.1a	61.2a	174.9a	64.3a	9.2a	0.62a	15.3b	231a
2	239.9a	72.2ab	79.7a	3.2a	63.3a	176.6a	63.3a	9.1a	0.61ab	17.3ab	323a
3	234.3ab	75.4a	77.4ab	3.4a	65.0a	169.3ab	54.8c	9.1a	0.57ab	16.2ab	213a
4	245.5a	74.9ab	79.4ab	3.2a	64.1a	181.4a	61.4ab	9.1a	0.54ab	17.2ab	235a
5	215.9b	71.5b	76.7b	3.1a	57.9a	158.0b	56.8bc	9.1a	0.51b	18.1a	221a

[1] 1. control, 2. 10 mM KNO_3+15 mM $CaSO_4$+ 10 mM KH_2PO_4 , 3. 15 mM $CaSO_4$+ 60 mM KH_2PO_4 , 4. 15 mM $CaSO_4$, 5. 60 mM KH_2PO_4

[2] Significant in comparison with control at P = 0.05 (LSD test).

椪柑果實養分分析

豐原試驗區果實鋅含量，以葉面噴施15 mM硫酸鈣而顯著降低，而鐵含量則以葉面噴施15 mM硫酸鈣+60 mM磷酸一鉀或15 mM硫酸鈣顯著降低(表九)。東勢試驗區葉面噴施15 mM硫酸鈣會降低果實磷含量，而葉面噴施10 mM 硝酸鉀+15 mM硫酸鈣+10 mM磷酸一鉀則可增加果實鈣含量(表十)。

表九、豐原椪柑果實養分分析

Table 9. Analysis of Ponkan fruit nutrients after foliar fertilizations in Fengyuan experimental orchard

Treatment[1]	N	P	K	Ca	Mg	Cu	Mn	Zn	Fe	B
	g/kg					mg/kg				
1	9.3a[2]	1.4a	12a	2.8a	1.1a	4.3a	3.3a	5.3ab	18ab	19a
2	8.2a	1.4a	12a	2.5a	1.0a	4.0a	3.0a	5.0abc	13bc	18a
3	7.5a	1.3a	11a	2.5a	1.0a	3.3a	2.7a	4.3bc	12c	18a
4	8.4a	1.4a	11a	2.6a	1.0a	3.3a	3.3a	4.0c	12c	18a
5	8.3a	1.4a	12a	2.6a	1.0a	4.0a	3.3a	5.7a	19a	18a

[1] 1. control, 2. 10 mM KNO_3+15 mM $CaSO_4$+ 10 mM KH_2PO_4, 3. 15 mM $CaSO_4$+ 60 mM KH_2PO_4, 4. 15 mM $CaSO_4$, 5. 60 mM KH_2PO_4

[2] Significant in comparison with control at P = 0.05 (LSD test).

表十、東勢柑橘果實養分分析

Table 10. Analysis of Ponkan fruit nutrients after foliar fertilizations in Dongshi experimental orchard

Treatment[1]	N	P	K	Ca	Mg	Cu	Mn	Zn	Fe	B
	g/kg					mg/kg				
1	7.2a[2]	1.7a	14a	4.1b	1.5a	6.5a	7.2a	11.2a	28a	15a
2	7.9a	1.8a	15a	4.5a	1.7a	5.0a	6.3a	7.0a	21a	15a
3	7.9a	1.8a	14a	3.9b	1.5a	3.8a	6.3a	6.0a	16a	15a
4	6.6a	1.3b	14a	4.1b	1.6a	3.8a	6.0a	6.8a	35a	14a
5	7.3a	1.8a	15a	4.2ab	1.5a	3.5a	6.0a	5.5a	15a	15a

[1] 1. control, 2. 10 mM KNO_3+15 mM $CaSO_4$+ 10 mM KH_2PO_4, 3. 15 mM $CaSO_4$+ 60 mM KH_2PO_4, 4. 15 mM $CaSO_4$, 5. 60 mM KH_2PO_4.

[2] Significant in comparison with control at P = 0.05 (LSD test).

結　論

本試驗結果顯示，於4月份及7月份葉面噴施養液，可提升椪柑果實品質，並具應用於減少颱風對其損害之潛力。其中，植體氮含量充足搭配葉面噴施60 mM磷酸一鉀可增加椪柑糖酸比，然而植體氮含量不足，葉面噴施磷酸一鉀，雖可提高椪柑果實糖酸比，然而會降低果實大小、果肉重及榨汁率。葉片養分分析結果顯示，葉片氮鉀比降低至1.3即可能發生果實榨汁率下降情形。葉面噴施養液效果應搭配土壤施肥管理，確實掌握樹體養分狀況，即可藉由葉面施肥提高椪柑果實品質。

參考文獻

1. 吳正宗　2008　微量要素　p.67-69　土壤與肥料分析手冊(一)　土壤化學性質分析　中華土壤肥料學會編印。
2. 張致盛、陳怡靜、張林仁　2009　臺灣果樹農業氣象災害與因應策略　作物、環境與生物資訊 6: 61-71。
3. 黃子彬　2010　全球氣候變遷對台灣果樹產業之影響與因應對策　p.1-25　宜蘭地區果樹產業發展研討會專刊。
4. 嚴夢如　1972　柑桔葉片分析在施肥上之應用 農業研究 21(4): 250-255。
5. Boman, B. J. 2001. Foliar nutrient sprays influence yield and size of Valencia orange. Proc. Fla. State. Hort. Soc. 114: 83-88.
6. Datta, S. K. and D. S. Mikkelsen. 1985. Potassium nutrition of rice. p. 665-699. In: Munson, R. D. (eds.). Potassium in agriculture. ASA, Madison, Wisconsin. USA.
7. EI-Tanany, M. M., M. N. Abdel Messih and M. A. Shama. 2011. Effects of foliar application with potassium, calcium and magnesium on yield, fruit quality and mineral composition of Washington navel orange trees. Alexandria Science Exchange Journal 32: 65-75.

8. Fullelove, G., K. Walsh, P. Subedi, R. Shaw and G. Pinnington. 2004. Final report: CT03029 Management of internal dryness of imperial mandarins. Horticulture Australia Ltd., Final project report No., Rockhampton.
9. Kant, S. and U. Kafkafi. 2002. Potassium and abiotic stresses in plants. P.233-251. In: Pasricha N. S. and S. K. Bansal (eds.). Potassium for sustainable crop production. Potash Institute of India, Gurgaon.
10. Keeney, D. R. and D. W. Nelson. 1982. Nitrogen-inorganic forms. p.643-698. In: Page, A. L., R. H. Miller and D. R. Keeney (eds.). Methods of Soil Analysis Part 2. Academic Press, Inc., New York.
11. Kundsen, D. and G. A. Peterson. 1982. Lithium, sodium, and potassium. p.225-246. In: Page, A. L., R. H. Miller and D. R. Keeney (eds.). Methods of Soil Analysis. Part 2. Academic Press, Inc., New York.
12. Lanyon, L. E. and W. R. Heald. 1982. Magnesium, calcium, strontium, and barium. p.247-262. In: Page, A. L., R. H. Miller and D. R. Keeney (eds.). Methods of Soil Analysis Part 2. Academic Press, Inc., New York.
13. Lowther, J. R. 1980. Use of single sulfuric acid hydrogen peroxide disgest for the analysis of Pinus radiata, needles. Commun. Soil Sci. Plant Analysis 11: 175-188.
14. Olsen, S. R. and L. E. Sommers. 1982. Phosphorus. p.403-430. In: Page, A. L., R. H. Miller and D. R. Keeney (eds.). Methods of Soil Analysis. Part 2. Academic Press, Inc., New York.
15. Rahman, M. and Z. K. Punja. 2009. Calcium and plant disease. P.57-78. In:Datnoff, L. E., W.H. Elmer, and D.M. Huber (eds.). Mineral Nutrient and Plant Disease.
16. Shirgure, P. S. and A. K. Srivastava. 2015. Potassium fertigation in Nagpur Mandarin. P.175-176 in: Goyal, M. R (eds.). Sustainable micro irrigation management for trees and vines. Apple academic press, Toronto New Jersey.
17. Uchida, R. 2000. Recommended plant tissue nutrient levels for some vegetable, fruit, and ornamental foliage and flowering plants in Hawaii. p. 61. In: Silva, J.A. and R. Uchida (eds.). Plant nutrient management in Hawaii's soils. Approaches for tropical and subtropical agriculture. College of tropical agriculture and human resources, university of Hawaii at Manoa.
18. Yoshida, S., D. A. Forno, J. H. Cock and K. A. Gomez. 1976. Procedures for routine analysis of zinc, copper, manganese, calcium, magnesium, potassium, and sodium by atomic absorption spectrophotometry and flame photometry. p. 27-34. In: Yoshida, S., D. A. Forno, J. H. Cock and K. A. Gomez (eds.). Laboratory manual for physiological studies of rice. IRRI. Philippines.

Influence of Foliar Application on Leaf Characteristic and Fruit Quality of Citrus (*Citrus poonensis* Hort.)[1]

You-Hong Zeng[2], Ya-Wen Kuo[2] and Hong-Tang Chen[2]

ABSTRACT

The citrus cultivar 'Ponkan' was subjected to foliar application of four nutrient solutions as follows (1) 10 mM KNO_3+15 mM $CaSO_4$+ 10 mM KH_2PO_4, (2) 15 mM $CaSO_4$+ 60 mM KH_2PO_4, (3) 15 mM $CaSO_4$ and (4) 60 mM KH_2PO_4, in order to investigate the influence on fruit quality and wind resistance. The control experiment was foliar application with tap water. In the experimental orchard in the Fengyuan District, the concentration of nitrogen, phosphorous and potassium in the citrus leaf among these treatments were all in the suitable nutrient levels, and foliar application of 15 mM $CaSO_4$+ 60 mM KH_2PO_4 or 60 mM KH_2PO_4 could increase phosphorous concentration in the leaf; foliar application of 15 mM $CaSO_4$ or 60 mM KH_2PO_4 can increase calcium concentration in the leaf as well as with increasing fruit TSS/acid ratio. Foliar application of the four nutrient solutions can decrease fruit dropping rate after the typhoon Soudelor in the experimental orchard in the Fengyuan District. In the experimental orchard in the Dongshi District, the citrus were nitrogen deficiency and foliar application of 60 mM KH_2PO_4 can significantly increase phosphorous and potassium concentration in the leaf resulting in decreasing the fruit length, pulp weight, acidity and juice content, but increasing the TSS/acid ratio. Decreasing juice content is also found in foliar spray of 15 mM $CaSO_4$+ 60 mM KH_2PO_4 followed by analysis of the leaf nutrition in the two treatments showed the N/K ratio in citrus leaf lower than 1.3 might cause the unfavorable effect. Experimental results showed foliar application of 60 mM KH_2PO_4 under optimal nitrogen content in the leaf could maintain citrus fruit characteristics and increase fruit TSS/acidity. Besides, foliar fertilization could be a potential approach for decreasing typhoon-caused damages in fruit trees.

Key words: citrus, foliar fertilization, fruit quality

---

[1] Contribution No. 0912 from Taichung DARES, COA.

[2] Assistant Researcher of Taichung DARES, COA.