

番荔枝果實黑點病之原因探討

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摘 要

番荔枝果實黑點病的原因經1994年的調查結果顯示正常果之果皮及果肉Ca含量均極顯著高於黑點病者，為確認其因，本（1995）年以幼果、成熟果及不同罹病程度的果實分析Ca含量作為診斷正常果與黑點病果的差異性，並建立Ca營養診斷基準。從未發生黑點病的番荔枝果園與發生黑點病嚴重的果園土壤及葉片Ca含量無法得知黑點病是否為缺Ca所引起。夏期果正常果幼果鮮物重及乾物重Ca平均含量分別為 20.6及82.6 mg/100g與黑點病之14.8及56.5 mg/100g有顯著的差異，成熟果之正常果分別為27.9及95.2 mg/100g顯著高於黑點病之16.1及53.5 mg/100g，冬期果成熟果不同罹病程度之果皮及果肉Ca含量彼此之間雖無顯著差異存在，但似有罹病程度愈重者Ca含量愈少的趨勢，罹病不同程度A（黑點病面積75%以上）、B（50—75%）、C（25—50%）、D（12.5—25%）、E（0.1—12.5%）及F（未發生），其果肉鮮物重及乾物重Ca平均含量分別為12.7、13.1、11.2、12.5、14.4、16.3及41.3、41.3、37.5、42.4、51.3、56.4 mg/100g，而果皮則分別為19.8、22.6、22.7、27.7、28.8、34.6及64.2、74.2、68.4、83.2、89.0、99.6 mg/100g。顯然黑點病與果皮Ca含量的相關性比果肉為高，因此診斷部位以果皮為佳。

暫定Ca含量的診斷基準為幼果70 mg/100g dry，夏期果及冬期果之果皮為33mg/100g fresh，90 mg/100g dry，即低於此濃度有缺Ca的可能而發生果實黑點病。

關鍵詞：番荔枝、黑點病、鈣缺乏。

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前 言

番荔枝 (*Annona squamosa* L.) 爲台東縣最重要的經濟果樹，栽培面積4,219公頃⁽¹⁾ 占全省之78%，近年來，果實發生黑點病日趨嚴重，此病之特徵(圖1)爲果實表面呈現褐至黑的小斑點，於鱗目或鱗溝，果頂、果腰或果底均會發生，但通常出現於果實的底部或腰部，發生之程度不一，輕者祇有寥寥幾點，較重者則局限於數處，嚴重者則幾乎布滿整粒果實，顏色輕者黑點細小而淡，重者粗大而深，此黑點實際上發生於果皮下方且不侵入果肉內⁽²⁾。此種黑點病的症狀與蠹蟬類爲害造成果皮形成粗糙的黑褐色斑點⁽⁴⁾，或由 *Cylindrocladium* 病菌造成果實果皮1-2mm暗紫至黑之斑點病⁽²¹⁾的初期症狀相類似。

番荔枝果實黑點病經初步調查結果⁽²⁾ 顯示正常果之果肉及果皮Ca含量均極顯著高於黑點病者，疑爲缺鈣所引起，爲進一步探討確認其因，本年(1995)以幼果、成熟果及不同罹病程度之成熟果分析果實Ca含量作爲診斷黑點病與正常果之差異性，並建立果實黑點病之診斷基準及部位。

材料與方法

果園土壤及葉片之分析

於發生黑點病嚴重的番荔枝果園及未發生黑點病的正常果園分別採土壤及植體葉片分析其土壤性質及營養元素的差異性。

果實礦物質含量的分析

於台東縣卑南鄉及東河鄉之番荔枝果園(本地粗鱗種)發生果實黑點病之果樹及同一果園或鄰近果園無發生果實黑點病之果樹，分別採取幼果或成熟果分析全粒或果肉及果皮的礦物質、果皮率、水分等。

果品分析方法

1. 乾物重測定：以105°C烘乾過夜定量測出水分含量後，以100減去水分含量。
2. 灰分分析⁽⁸⁾：依據A. O. A. C之灰化法測定。
3. 碳物質組成分分析：以測定灰分後之果肉及果皮灰化樣品，以3N鹽酸5ml

加熱溶出礦物質元素，並加入0.2N鹽酸稀釋至50ml後，用感應耦合漿—原子發光譜儀（Inductively Coupled Plasma-Atomic Emission spectrophotometer，簡稱ICP-AES, Jobin-JY 38 Type III），測定S、P、Na、Mg、Fe、Mn、Cu、Zn、B、Al等元素含量。

4. 粗蛋白質含量測定：精稱2g鮮物樣品以Semimicro Kjeldahl方法測定N%， $N\% \times 6.25$ 即為粗蛋白質含量。

結果及討論

於84年11月中旬在台東市選擇一處無發生果實黑點病的果園及在卑南鄉選擇一處發生果實黑點病嚴重的果園，分別採土壤及葉片分析其大量及微量元素含量（表一、二），結果顯示正常果園之土層祇有20公分深，為有機質含量少。

表一、果園土壤分析結果

Table 1. Soil property analysis of orchards.

| Status of orchard | Soil layer | pH | OM % | ppm | | | |
|-------------------|----------------|-----|------|------|------|-------|-------|
| | | | | Av-P | Ex-K | Ex-Ca | Ex-Mg |
| N ¹ | T ¹ | 5.6 | 1.7 | 69 | 62 | 338 | 28 |
| B | T | 5.9 | 3.5 | 52 | 159 | 1975 | 342 |
| | S | 5.9 | 2.3 | 16 | 80 | 1488 | 451 |

¹: N, B, T and S indicate normal fruit, black speck disease fruit, surface soil and subsoil, respectively.

表二、葉片營養分析結果

Table 2. Leaf nutrients composition analysis.

| Status of orchard | % | | | ppm | | | | | | |
|-------------------|------|------|------|------|------|------|------|-----|------|------|
| | N | P | K | Ca | Mg | Fe | Mn | Cu | Zn | B |
| N ¹ | 2.92 | 0.11 | 1.38 | 3.29 | 0.47 | 34.7 | 84.3 | 7.1 | 10.8 | 48.9 |
| B | 3.18 | 0.12 | 0.81 | 2.43 | 0.16 | 40.0 | 26.7 | 7.8 | 10.5 | 50.0 |

¹N and B the same as table 1.

而微酸性的砂質壤土，交換性Ca的含量為338ppm，顯然濃度在缺乏的含量之下⁽⁶⁾，但葉片分析的結果Ca含量為3.29%，卻在不虞缺乏的含量範圍^(5,13)，可見植體對Ca的吸收良好。卑南鄉果園之土層約為40公分，為富有機質而微酸性的坩質壤土，交換性Ca的含量表土1975ppm、底土1488ppm，葉片含量為2.43%，顯然均在充足的含量範圍，但整個果園的果實大多發生嚴重的黑點病，此可能與果園的管理及環境有關，因其番荔枝果園間作高大的椰子樹致果園之陽光照射不足，且無灌溉設施果園土壤常呈乾燥與堅硬狀態，加上園主年邁力衰無法有效管理果園導致病蟲為害嚴重。根據第一年(1994)調查的結果⁽²⁾認為果實黑點病似為缺Ca所引起，而土壤過乾時土壤中雖有鈣質也不易被根群吸收，土壤太緊密通風不良也會影響根群對鈣質的吸收⁽³⁾，鈣主要靠蒸散流移動⁽¹⁸⁾，當果園日照不良蒸散流降低則影響鈣的吸收及移動，由此可知發生黑點病的果樹土壤鈣雖然不缺，但因生長環境不利鈣的吸收而造成果實似因缺鈣而罹患黑點病。

於84年夏期果分別在台東市及卑南鄉採番荔枝果實供分析其礦物質，其結果如表三所示，顯然無論6月28日或8月5日採樣的幼果及成熟果，其正常果與黑

表三、夏期果全粒果實礦物質成分分析

Table 3. Whole fruit mineral composition analysis of summer fruits

| Item | Fresh weight basis | | | | Dry weight basis | | | |
|-------------------|--------------------|---------------------|--------|---------------------|------------------|---------------------|--------|---------------------|
| | Jun. 28 | | Aug. 5 | | Jun. 28 | | Aug. 5 | |
| | Normal | Black speck disease | Normal | Black speck disease | Normal | Black speck disease | Normal | Black speck disease |
| Fruit wt.(g) | 84.8 | 84.3 | 310.2 | 291.9 | 84.8 | 84.3 | 310.2 | 291.9 |
| Moisture(%) | 75.0 | 73.7 | 70.4 | 69.4 | 75.0 | 73.7 | 70.4 | 69.4 |
| Crude protein (%) | 3.05 | 2.96 | — | — | 12.2 | 11.2 | — | — |
| Ash (%) | 0.95 | 0.93 | 1.15 | 1.13 | 3.82 | 3.57 | 3.91 | 3.72 |
| S | 22 | 24 | 26 | 26 | 90 | 92 | 89 | 84 |
| P | 69 | 68 | 60 | 65 | 277 | 259 | 203 | 214 |
| Na | 4 | 4 | 8 | 9 | 17 | 16 | 28 | 30 |
| K | 425 | 423 | 508 | 485 | 1703 | 1614 | 1719 | 1588 |
| Ca (mg/100g) | 20.6 | 14.8 | 27.9 | 16.1 | 82.6 | 56.5 | 95.2 | 53.5 |
| Mg | 41 | 41 | 38 | 43 | 166 | 156 | 129 | 141 |
| Fe | 0.63 | 0.82 | 0.55 | 0.63 | 2.54 | 3.14 | 1.87 | 2.05 |
| Mn | 0.32 | 0.26 | 0.29 | 0.33 | 1.29 | 1.00 | 0.98 | 1.07 |
| Cu | 0.18 | 0.20 | 0.22 | 0.25 | 0.72 | 0.77 | 0.75 | 0.81 |
| Zn | 0.39 | 0.38 | 0.22 | 0.29 | 1.56 | 1.48 | 0.74 | 0.94 |
| B | 0.23 | 0.23 | 0.30 | 0.32 | 0.95 | 0.88 | 1.01 | 1.06 |
| Al | 0.65 | 0.50 | 0.80 | 0.55 | 2.64 | 1.91 | 2.72 | 1.82 |

表四、夏期果全粒果實鈣含量

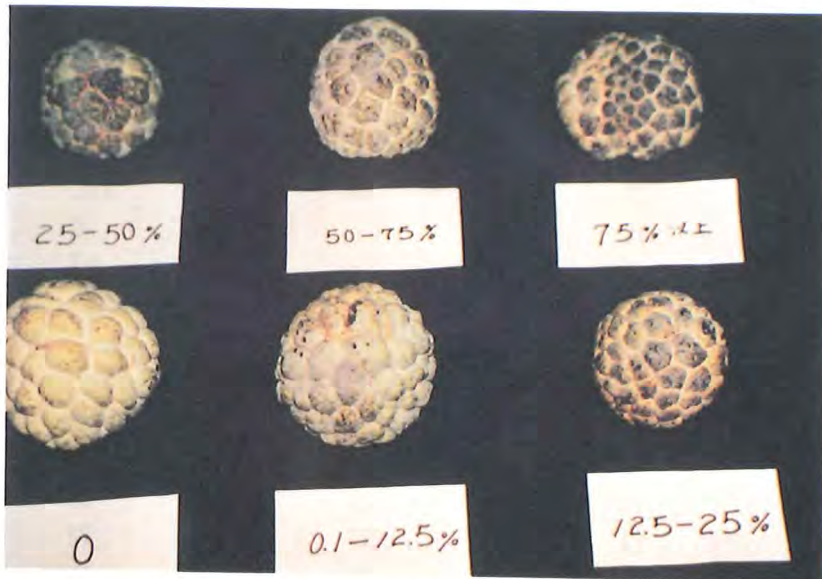
Table 4. Whole fruit Ca content of summer fruits.

| Symptom | Ca (mg/100g fresh wt.) | | | Ca (mg/100g dry wt.) | | | |
|---------------------|------------------------|----------|-----------------|----------------------|----------|-----------------|----|
| | 6/28 | 8/5 | | 6/28 | 8/5 | | |
| Normal | 20 ^a | 19 | 20 ^a | 75 ^a | 61 | 78 ^a | |
| | 17 | 20 | 23 | 69 | 78 | 81 | |
| | 22 | 31 | 19 | 89 | 86 | 63 | |
| | 18 | 39 | 28 | 70 | 137 | 107 | |
| | 29 | 31 | 38 | 118 | 112 | 136 | |
| | 18 | 31 | 40 | 75 | 82 | 122 | |
| | | | 47 | 13 | | 173 | 50 |
| | | | 26 | 18 | | 72 | 67 |
| | | | 22 | 28 | | 89 | 95 |
| | | | 31 | | | 100 | |
| | | 35 | | | 115 | | |
| Black speck disease | 12 ^b | 9 | 17 ^b | 49 ^b | 26 | 54 ^b | |
| | 11 | 12 | 30 | 41 | 33 | 93 | |
| | 14 | 11 | 20 | 57 | 34 | 72 | |
| | 17 | 27 | 20 | 61 | 81 | 76 | |
| | 15 | 10 | 9 | 58 | 29 | 36 | |
| | 20 | 6 | 20 | 73 | 23 | 68 | |
| | | | 10 | 18 | | 30 | 68 |
| | | | 21 | 15 | | 62 | 57 |
| | | | 15 | 15 | | 53 | 58 |
| | | | 21 | 18 | | 59 | 61 |
| | | 17 | 14 | | 62 | 44 | |
| | CV=22.2% | CV=34.4% | | CV=22% | CV=34.4% | | |
| | P=0.05 | P=0.01 | | P=0.05 | P=0.01 | | |

點病全粒果實之果重、含水率、粗蛋白質、灰分、S、P、Na、K、Mg、Fe、Mn、Cu、Zn、B、Al等含量均無多大差異，但所含Ca量，不論以鮮物重或乾物重計算，均有明顯差異（表四），6月28日所採幼果，全粒幼果Ca平均含量正常果為20.6 mg/100g fresh wt. 或82.6

mg/100g dry wt. 而黑點病果為4.8 mg/100g fresh wt. 或56.5mg/100g dry wt.，顯然無論以鮮物重或乾物重計算Ca含量，正常果均顯著高於黑點病果。8月5日所採成熟果，全粒果實Ca平均含量正常果為27.9 mg/100g fresh wt. 或95.2 mg/100g dry wt. 而黑點病果則為16.1 /100g fresh wt. 或53.5mg/100g dry wt. 顯示不論以鮮物重或乾物重計算Ca含量，正常果均呈極顯著高於黑點病果。

為要瞭解黑點病不同罹病程度與Ca量的關係，於冬期果在卑南鄉及東河鄉分別採樣分析，以黑點病所占果實表面積的多寡作為區分，分成六級（圖一）



圖一、番荔枝果實黑點病之不同罹病程度

Fig. 1. Different black speck disease index of sugar apples

，A級為罹病面積75%以上、B 50—75%、C 25—50%、D 12.5—25%、E 0.1—12.5%、F 0%（正常果）。冬期果於12月15日及翌年1月5日分別採樣分析果皮及果肉礦物質的結果（表五—八），果實黑點病罹病程度與Ca有所差異外，其餘如果重、含皮率、水分、灰分、S、P、Na、K、Mg、Fe、Mn、Cu、Zn、B及Al均無顯著性差異。

冬期果12月15日採樣的果實，Ca含量分析結果（表九），其果皮Ca平均含量以鮮物重計A、B、C、D、E及F級分別為18.5、23.2、24.0、31.0、32.0及36.1mg/100g，而果肉則分別為13.7、14.2、12.0、13.3、16.3及16.4 mg/100g；果皮以乾物重計A、B、C、D、E及F級分別為59.5、71.0、66.1、86.0、90.0及99.0 mg

/100g，果肉則分別為47.2、47.2、46.8、49.6、59.3及60.7mg/100g。顯示不論果皮或果肉Ca的含量以乾物重計算均高於鮮物重計算者。果皮各級間Ca的含量有顯著的差異，似乎果實黑點病罹病程度愈高所含Ca的濃度愈低，即正常果Ca含量最高而罹病面積75%以上者Ca含量似乎最低。果肉無論是以鮮物重或乾物重計算，各級間Ca的含量均呈不顯著的差異，但正常果Ca含量均比黑點病果高。果皮Ca含量不論鮮物重或乾物重均高於果肉含量，果實黑點病與果皮Ca含量較有相關而與果肉Ca含量的關係較小。

表五、冬期果果皮礦物質成分分析 (Dec. 15, 1995)

Table 5. Skin mineral composition analysis of winter fruits(Dec.15,1995).

| Item | Fresh weight basis | | | | | | Dry weight basis | | | | | |
|------------------------|--------------------|-------|-------|-------|-------|-------|------------------|-------|-------|-------|-------|-------|
| | A ¹ | B | C | D | E | F | A | B | C | D | E | F |
| Fruit wt.(g) | 310.2 | 343.6 | 315.1 | 315.9 | 314.6 | 338.8 | 310.2 | 343.6 | 315.1 | 315.9 | 314.6 | 338.8 |
| Percentage (%) of skin | 52.6 | 49.3 | 42.1 | 48.2 | 49.0 | 49.1 | 52.6 | 49.3 | 42.1 | 48.2 | 49.0 | 49.1 |
| Moisture (%) | 68.2 | 67.6 | 63.7 | 65.7 | 64.1 | 64.7 | 68.2 | 67.6 | 63.7 | 65.7 | 64.1 | 64.7 |
| Ash (%) | 1.18 | 1.19 | 1.33 | 1.22 | 1.24 | 1.34 | 3.74 | 3.70 | 3.72 | 3.59 | 3.50 | 3.85 |
| S | 22 | 22 | 23 | 19 | 22 | 24 | 71 | 68 | 63 | 57 | 62 | 70 |
| P | 72 | 62 | 74 | 70 | 73 | 71 | 228 | 192 | 207 | 206 | 205 | 206 |
| Na | 6 | 7 | 4 | 5 | 7 | 15 | 18 | 21 | 11 | 15 | 20 | 42 |
| K | 540 | 532 | 608 | 519 | 544 | 570 | 1703 | 1648 | 1691 | 1523 | 1522 | 1633 |
| Ca | 18.5 | 23.2 | 24.0 | 31.0 | 32.0 | 36.1 | 59.5 | 71.0 | 66.1 | 86.0 | 90.0 | 99.0 |
| Mg(mg/100g) | 34 | 34 | 33 | 34 | 35 | 37 | 106 | 106 | 93 | 99 | 96 | 106 |
| Fe | 0.90 | 0.82 | 0.73 | 0.73 | 0.92 | 0.67 | 2.96 | 2.55 | 2.02 | 2.16 | 2.62 | 1.97 |
| Mn | 0.27 | 0.41 | 0.35 | 0.28 | 0.30 | 0.28 | 0.89 | 1.29 | 0.97 | 0.84 | 0.84 | 0.82 |
| Cu | 0.31 | 0.30 | 0.36 | 0.29 | 0.28 | 0.27 | 0.99 | 0.93 | 1.02 | 0.87 | 0.79 | 0.80 |
| Zn | 0.25 | 0.25 | 0.26 | 0.27 | 0.24 | 0.22 | 0.81 | 0.80 | 0.74 | 0.82 | 0.69 | 0.68 |
| B | 0.30 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.97 | 0.98 | 0.88 | 0.92 | 0.88 | 0.88 |
| Al | 0.72 | 0.83 | 0.79 | 0.90 | 1.41 | 1.21 | 2.34 | 2.58 | 2.21 | 2.66 | 3.95 | 3.52 |

¹A, B, C, D, E and F stand for black speck disease area 75% over, 50-70%, 25-50%, 12.5-25%, 0.1-12.5% and 0% (non), respectively.

表六、冬期果果肉礦物質成分分析 (Dec. 15, 1995)

Table 6. Pulp mineral composition analysis of winter fruits (Dec. 15, 1995).

| Item | Fresh weight basis | | | | | | Dry weight basis | | | | | |
|---------------|--------------------|-------|-------|-------|-------|-------|------------------|-------|-------|-------|-------|-------|
| | A ¹ | B | C | D | E | F | A | B | C | D | E | F |
| Fruit wt. (g) | 343.3 | 343.7 | 315.1 | 316.0 | 314.6 | 338.8 | 343.3 | 343.7 | 315.1 | 316.0 | 314.6 | 338.8 |
| Moisture (%) | 70.3 | 70.5 | 71.5 | 72.8 | 71.4 | 72.1 | 70.3 | 70.5 | 71.5 | 72.8 | 71.4 | 72.1 |
| Ash (%) | 0.74 | 0.77 | 0.74 | 0.76 | 0.78 | 0.80 | 2.53 | 2.33 | 2.64 | 2.79 | 2.74 | 2.88 |
| S | 6 | 6 | 6 | 6 | 6 | 6 | 20 | 19 | 20 | 23 | 22 | 22 |
| P | 46 | 41 | 43 | 41 | 41 | 44 | 158 | 141 | 153 | 152 | 147 | 158 |
| Na | 8 | 7 | 6 | 7 | 6 | 11 | 26 | 23 | 21 | 28 | 23 | 20 |
| K | 335 | 339 | 349 | 311 | 304 | 327 | 1144 | 1150 | 1239 | 1139 | 1085 | 1170 |
| Ca | 13.7 | 14.2 | 12.0 | 13.3 | 16.3 | 16.4 | 47.2 | 47.2 | 46.8 | 49.6 | 59.3 | 60.7 |
| Mg(mg/100g) | 30 | 31 | 27 | 29 | 27 | 31 | 104 | 104 | 97 | 111 | 97 | 112 |
| Fe | 0.28 | 0.23 | 0.22 | 0.28 | 0.26 | 0.24 | 0.95 | 0.78 | 0.78 | 1.07 | 0.93 | 0.88 |
| Mn | 0.19 | 0.16 | 0.15 | 0.15 | 0.12 | 0.14 | 0.65 | 0.53 | 0.54 | 0.55 | 0.43 | 0.49 |
| Cu | 0.13 | 0.11 | 0.12 | 0.11 | 0.09 | 0.10 | 0.44 | 0.37 | 0.43 | 0.40 | 0.31 | 0.36 |
| Zn | 0.19 | 0.15 | 0.18 | 0.18 | 0.19 | 0.17 | 0.65 | 0.51 | 0.66 | 0.68 | 0.67 | 0.62 |
| B | 0.13 | 0.14 | 0.13 | 0.13 | 0.12 | 0.14 | 0.46 | 0.47 | 0.45 | 0.47 | 0.42 | 0.50 |
| Al | 0.58 | 0.48 | 0.40 | 0.57 | 0.52 | 0.53 | 1.99 | 1.63 | 1.44 | 2.17 | 1.85 | 1.88 |

¹A, B, C, D, E, and F the same as table 5.

表七、冬期果果皮礦物質成分分析 (Jan. 5, 1996)

Table 7. Skin mineral composition analysis of winter fruits (Jan. 5, 1996).

| Item | Fresh weight basis | | | | | | Dry weight basis | | | | | |
|--------------------------|--------------------|-------|-------|-------|-------|-------|------------------|-------|-------|-------|-------|-------|
| | A ¹ | B | C | D | E | F | A | B | C | D | E | F |
| Fruit wt.(g) | 422.5 | 424.8 | 438.4 | 436.0 | 370.3 | 339.8 | 422.5 | 424.8 | 438.4 | 436.0 | 370.3 | 339.8 |
| Percentage(%) of skin | 46.9 | 54.5 | 47.8 | 51.3 | 51.7 | 49.2 | 46.9 | 54.5 | 47.8 | 51.3 | 51.7 | 49.2 |
| Moisture (%) | 69.1 | 71.6 | 70.0 | 69.7 | 70.5 | 66.9 | 69.1 | 71.6 | 70.0 | 69.7 | 70.5 | 66.9 |
| Ash (%) | 1.03 | 1.01 | 0.98 | 0.98 | 1.01 | 1.03 | 3.35 | 3.56 | 3.29 | 3.24 | 3.43 | 3.14 |
| S | 14 | 16 | 15 | 15 | 16 | 14 | 47 | 56 | 49 | 50 | 53 | 42 |
| P | 57 | 60 | 56 | 56 | 58 | 50 | 187 | 211 | 188 | 184 | 196 | 153 |
| Na | 12 | 10 | 16 | 9 | 11 | 11 | 40 | 35 | 56 | 28 | 37 | 33 |
| K | 431 | 428 | 431 | 433 | 442 | 444 | 1405 | 1515 | 1443 | 1434 | 1504 | 1348 |
| Ca | 21.1 | 22.1 | 21.4 | 24.4 | 25.7 | 33.1 | 69.0 | 77.5 | 70.8 | 80.5 | 88.0 | 100.2 |
| Mg(mg/100g) | 28 | 31 | 29 | 30 | 31 | 32 | 91 | 109 | 96 | 99 | 104 | 97 |
| Fe | 0.51 | 0.51 | 0.53 | 0.50 | 0.52 | 0.50 | 1.65 | 1.82 | 1.78 | 1.67 | 1.78 | 1.52 |
| Mn | 0.22 | 0.22 | 0.22 | 0.24 | 0.25 | 0.26 | 0.72 | 0.79 | 0.73 | 0.79 | 0.83 | 0.78 |
| Cu | 0.22 | 0.24 | 0.23 | 0.21 | 0.23 | 0.18 | 0.73 | 0.84 | 0.76 | 0.71 | 0.77 | 0.56 |
| Zn | 0.19 | 0.21 | 0.21 | 0.20 | 0.24 | 0.19 | 0.63 | 0.74 | 0.69 | 0.65 | 0.80 | 0.59 |
| B | 0.26 | 0.25 | 0.27 | 0.27 | 0.27 | 0.28 | 0.84 | 0.87 | 0.91 | 0.90 | 0.92 | 0.85 |
| Al | 0.81 | 0.72 | 0.76 | 0.82 | 1.00 | 1.28 | 2.65 | 2.54 | 2.54 | 2.70 | 3.40 | 3.90 |

¹A, B, C, D, E, and F the same as table 5.

表八、冬期果果肉礦物質成分分析 (Jan. 5, 1996)

Table 6. Pulp mineral composition analysis of winter fruits (Jan. 5, 1996).

| Item | Fresh weight basis | | | | | | Dry weight basis | | | | | |
|---------------|--------------------|-------|-------|-------|-------|-------|------------------|-------|-------|-------|-------|-------|
| | A ¹ | B | C | D | E | F | A | B | C | D | E | F |
| Fruit wt. (g) | 448.1 | 424.8 | 438.4 | 436.0 | 370.3 | 339.8 | 448.1 | 424.8 | 438.4 | 436.0 | 370.3 | 339.8 |
| Moisture (%) | 66.3 | 66.1 | 63.2 | 66.4 | 71.0 | 68.5 | 66.3 | 66.1 | 63.2 | 66.4 | 71.0 | 68.5 |
| Ash (%) | 0.74 | 0.66 | 0.62 | 0.63 | 0.64 | 0.75 | 2.20 | 1.96 | 1.69 | 1.89 | 2.20 | 2.39 |
| S | 5 | 5 | 5 | 4 | 5 | 5 | 16 | 14 | 13 | 13 | 16 | 16 |
| P | 38 | 37 | 36 | 32 | 34 | 36 | 114 | 110 | 97 | 95 | 118 | 113 |
| Na | 18 | 20 | 22 | 16 | 15 | 15 | 53 | 59 | 61 | 47 | 51 | 49 |
| K | 303 | 265 | 260 | 248 | 248 | 283 | 901 | 782 | 709 | 739 | 860 | 898 |
| Ca | 11.8 | 12.0 | 10.4 | 11.7 | 12.5 | 16.2 | 35.5 | 35.4 | 28.2 | 35.2 | 43.4 | 52.1 |
| Mg(mg/100g) | 22 | 24 | 23 | 24 | 25 | 29 | 66 | 72 | 62 | 71 | 85 | 91 |
| Fe | 0.37 | 0.47 | 0.41 | 0.39 | 0.30 | 0.34 | 1.09 | 1.38 | 1.13 | 1.15 | 1.04 | 1.09 |
| Mn | 0.09 | 0.10 | 0.10 | 0.11 | 0.11 | 0.13 | 0.27 | 0.29 | 0.26 | 0.32 | 0.38 | 0.42 |
| Cu | 0.11 | 0.11 | 0.10 | 0.09 | 0.10 | 0.09 | 0.31 | 0.33 | 0.28 | 0.28 | 0.35 | 0.30 |
| Zn | 0.12 | 0.18 | 0.20 | 0.17 | 0.25 | 0.20 | 0.37 | 0.54 | 0.54 | 0.52 | 0.85 | 0.64 |
| B | 0.11 | 0.11 | 0.12 | 0.11 | 0.11 | 0.14 | 0.34 | 0.33 | 0.32 | 0.34 | 0.39 | 0.43 |
| Al | 1.17 | 1.63 | 1.31 | 1.41 | 1.15 | 1.18 | 3.47 | 4.81 | 3.57 | 4.19 | 3.98 | 3.75 |

¹A, B, C, D, E, and F the same as table 5.

表九、冬期果果實鈣含量 (Dec. 15, 1995).

Table 9. Fruit Ca content of winter fruits (Dec. 15, 1995).

| Part | Fresh weight basis | | | | | | Dry weight basis | | | | | | |
|---------|--------------------|----|----|-------|----|----|------------------|-----|-----|-------|-----|-----|-----|
| | A ¹ | B | C | D | E | F | A | B | C | D | E | F | |
| Skin | 14 | 23 | 16 | 27 | 31 | 33 | 47 | 70 | 44 | 89 | 98 | 88 | |
| | 28 | 21 | 39 | 33 | 41 | 53 | 96 | 64 | 117 | 94 | 111 | 143 | |
| | 17 | 34 | 23 | 47 | 25 | 54 | 55 | 101 | 60 | 107 | 63 | 137 | |
| | 15 | 18 | 24 | 25 | 30 | 37 | 40 | 59 | 59 | 79 | 94 | 101 | |
| | | | 20 | 24 | 32 | 37 | 35 | | 61 | 64 | 89 | 98 | 74 |
| | | | | 18 | 22 | 28 | 34 | | | 53 | 58 | 76 | 64 |
| | | | | | | | 26 | | | | | | 93 |
| | | | | | | | 31 | | | | | | 119 |
| | | | | | | | 30 | | | | | | 94 |
| | | | | | | | 28 | | | | | | 77 |
| p(0.05) | c | bc | bc | ab | ab | a | c | bc | bc | abc | ab | a | |
| p(0.01) | b | b | b | ab | ab | a | b | ab | b | ab | ab | a | |
| CV | | | | 27.9% | | | | | | 27.3% | | | |
| Pulp | 10 | 15 | 11 | 13 | 17 | 29 | 35 | 49 | 34 | 41 | 71 | 98 | |
| | 17 | 14 | 11 | 9 | 12 | 11 | 59 | 43 | 43 | 35 | 44 | 59 | |
| | 13 | 10 | 15 | 12 | 17 | 15 | 41 | 38 | 60 | 39 | 49 | 59 | |
| | 15 | 15 | 13 | 13 | 16 | 14 | 54 | 48 | 51 | 49 | 57 | 50 | |
| | | | 17 | 10 | 17 | 15 | | 58 | 48 | 70 | 87 | 55 | |
| | | | | 12 | 16 | 15 | 13 | | 45 | 64 | 48 | 47 | |
| | | | | | | | 17 | | | | | 59 | |
| | | | | | | | 18 | | | | | 63 | |
| | | | | | | | 16 | | | | | 58 | |
| | | | | | | | 16 | | | | | 59 | |
| p(0.05) | | | | NS | | | | | | NS | | | |
| CV | | | | 23.7% | | | | | | 24.2% | | | |

¹A, B, C, D, E, and F the same as table 5.

冬期果1月5日採樣的果實Ca含量分析結果（表十），其果皮Ca平均含量以

表十、冬期果果實鈣含量 (Jan. 5, 1996).

Table 10. Fruit Ca content of winter fruits (Jan. 5, 1996)

| Part | Fresh weight basis | | | | | | Dry weight basis | | | | | |
|---------|--------------------|----|-------|----|----|----|------------------|-------|----|-----|-----|-----|
| | A ¹ | B | C | D | E | F | A | B | C | D | E | F |
| Skin | 27 | 21 | 25 | 23 | 22 | 37 | 88 | 80 | 84 | 81 | 80 | 122 |
| | 19 | 22 | 19 | 25 | 22 | 33 | 61 | 78 | 63 | 87 | 74 | 90 |
| | 19 | 18 | 18 | 23 | 22 | 33 | 65 | 65 | 54 | 75 | 74 | 88 |
| | 20 | 25 | 19 | 30 | 26 | 35 | 65 | 87 | 63 | 98 | 92 | 105 |
| | 15 | 17 | 23 | 28 | 21 | 31 | 50 | 55 | 80 | 84 | 74 | 110 |
| | 27 | 24 | 18 | 18 | 32 | 28 | 85 | 84 | 63 | 58 | 116 | 103 |
| | | 28 | 28 | 24 | 35 | | | 94 | 89 | 81 | 123 | 84 |
| | | | | | 25 | | | | | 84 | | |
| | | | | | 26 | | | | | 84 | | |
| | | | | | 26 | | | | | 84 | | |
| | | | | | 24 | | | | | 90 | | |
| | | | | | 26 | | | | | 90 | | |
| | | | | | 26 | | | | | 81 | | |
| | | | | | 27 | | | | | 87 | | |
| | p(0.05) | c | bc | c | bc | b | a | c | bc | c | bc | ab |
| p(0.01) | b | b | b | b | b | a | c | bc | c | abc | ab | a |
| CV | | | 15.7% | | | | | 16.7% | | | | |
| Pulp | 16 | 13 | 11 | 12 | 11 | 20 | 48 | 38 | 29 | 34 | 39 | 65 |
| | 10 | 11 | 9 | 14 | 10 | 15 | 27 | 30 | 24 | 45 | 34 | 42 |
| | 11 | 10 | 9 | 10 | 12 | 16 | 30 | 28 | 28 | 31 | 39 | 52 |
| | 10 | 13 | 10 | 12 | 17 | 17 | 30 | 36 | 29 | 38 | 55 | 54 |
| | 16 | 9 | 10 | 12 | 8 | 18 | 53 | 28 | 25 | 35 | 29 | 58 |
| | 8 | 14 | 8 | 8 | 16 | 15 | 25 | 46 | 24 | 22 | 56 | 52 |
| | | 14 | 16 | 14 | 15 | 13 | | 42 | 39 | 42 | 55 | 42 |
| | | | | | 13 | | | | | | 43 | |
| | | | | | 12 | | | | | | 40 | |
| | | | | | 12 | | | | | | 43 | |
| | | | | | 13 | | | | | | 46 | |
| | | | | | 12 | | | | | | 41 | |
| | | | | | 11 | | | | | | 40 | |
| | | | | | 14 | | | | | | 48 | |
| | p(0.05) | b | b | b | b | b | a | c | c | c | c | b |
| p(0.01) | b | b | b | b | b | a | bc | bc | c | bc | ab | a |
| CV | | | 19.7% | | | | | 20.6% | | | | |

¹A, B, C, D, E, and F the same as table 5.

鮮物重計A、B、C、D、E及F分別為21.1、22.1、21.4、24.4、25.7及33.1

mg/100g，而果肉則分別為11.8、12.0、10.4、11.7、12.5及16.2 mg/100g；果皮以乾物重計A、B、C、D、E及F級分別為69.0、77.5、70.8、80.5、88.0及100.2 mg/100g，而果肉則分別為35.5、35.4、28.2、35.2、43.4及52.1 mg/100g。顯示不論果皮或果肉Ca含量均以乾物重高於鮮物重之計算值。果皮各級間鮮物重或乾物重Ca含量均呈極顯著的差異，似有果實黑點病罹病程度愈高所含Ca的含量愈低，即正常果Ca含量最高。果肉不管是以鮮物重或乾物重計算，各級間Ca的含量均呈極顯著的差異，仍有罹病程度愈高，所含Ca含量愈低的趨勢，而以正常果Ca含量最高。同樣地，果皮Ca含量不論鮮物重或乾物重均高於果肉含量。

番荔枝果實Ca濃度以種子含量最高，其次為果皮而以果肉最低⁽¹⁴⁾，冬期果正常果之果皮Ca鮮物重濃度正常果為33.1–36.1 mg/100g、平均34.6 mg/100g，黑點病者為18.5–32.0 mg/100g、平均24.3 mg/100g，乾物重濃度正常果為99.0–100.2 mg/100g、平均99.6 mg/100g，黑點病者59.5–90.0 mg/100g、平均75.8 mg/100g；冬期果正常果之果肉Ca鮮物重濃度為16.2–16.4 mg/100g、平均16.3 mg/100g，黑點病者10.4–16.3 mg/100g、平均12.7 mg/100g，乾物重濃度正常果為52.1–60.7 mg/100g、平均56.4 mg/100g，黑點病者28.2–59.3 mg/100g、平均42.7 mg/100g，亦顯示果皮Ca濃度高於果肉。果肉Ca濃度可能受品種、氣候、土質、栽培管理等因素的影響而有所差異，國外的報導番荔枝成熟果之果肉含鈣量有17.0⁽²⁵⁾、19.4⁽²⁰⁾、22.0⁽⁷⁾、28.0⁽¹⁷⁾及44.4⁽²⁴⁾ mg/100g，1994年之調查研究結果⁽²⁾Ca含量夏期果之果肉正常果與黑點病果分別為19.2及15.4 mg/100g fresh，果皮則分別為33.0及23.1 mg/100g fresh；冬期果之果肉正常果與黑點病果分別22.7及14.8 mg/100g fresh，果皮則分別為32.4及19.0 mg/100g fresh而本(1995)年冬期果之果肉正常果與黑點病果分別為16.3及12.7 mg/100g fresh，果皮則分別為34.6及24.3 mg/100g fresh，顯然果皮及果肉Ca含量因年期與黑點病的影響而有差異，因此診斷Ca含量是否充足或欠缺宜依期作、果實部位、分析方法等訂定之。

當高K、Mg或NH₄時可促進Ca的缺乏^(15, 19, 23)，但從表三、表五、表六、表七及表八可看出不論是夏期果之幼果、成熟果或冬期果之果皮及果肉，其K與Mg含量在正常果或黑點病果均無顯著的差異，可知黑點病果實Ca含量較正常果少的原因並非受K或Mg的影響。Brumon等人⁽¹¹⁾指出誘導鈣的缺乏最要的因子為氣象因子，Russel等人^(9, 21)亦指出Ca經根尖從土壤溶液運轉至上部的植體組織，因

此任何妨礙新根的生長因子如NH₄肥、土壤缺水、土壤過濕、通氣不良、低溫、高鹽分等均與Ca的缺乏有關，縱然土壤有充分Ca的供應亦會發生缺Ca現象Kirbby⁽¹⁶⁾曾指出田間作物缺鈣的發生並非Ca供應的不足而是植體內Ca分布的不足，Ca的吸收主要為被動的方式，Ca在植體內的運轉亦然，Ca在木質部汁液內往上運輸受蒸散流的影響，故蒸散流的強度有相當程度控制Ca往上運轉的速率，因此Ca不容易移至蒸散率低的器官如果實、閉鎖的尖端、迅速生長的葉等，但活躍蒸散的葉則Ca移入，所以Ca的缺乏較易發生於果實和葉尖且常發出於受影響器官較向基的區域⁽¹⁰⁾，而植體組織缺Ca最終會因細胞的化合物的氧化而導致組織褪色或褐色⁽⁹⁾。Chiu等人⁽¹²⁾指出以葉片Ca的含量作為診斷果實的指標是不可靠的，因Ca在植物體內多積聚在老葉，且其移動緩慢並靠蒸散流傳導，故蒸散率低的果實，Ca的移動不如蒸散率高的葉片來得快，所以Ca的缺乏較易在果實發生。由此假定果實黑點病係因Ca的缺乏所造成，則土壤中鈣的供應，土壤中有效性或交換性Ca的含量及葉片Ca濃度均不適宜作為診斷的依據，故以果實Ca的含量作為營養診斷指標為宜。

由於果實黑點病與果皮Ca含量較果肉Ca含量之相關性較佳，因此以果皮部位作為診斷Ca含量基準較適宜，冬期果果皮Ca含量以鮮物重計則其暫定基準為33 mg/100g，乾物重則為90 mg/100g，即低於此含量則有缺Ca之虞。夏期果因係整粒果實分析Ca含量故以整粒Ca含量作為診斷基準，由於果實黑點病與乾物重Ca含量之相關性比鮮物重為佳，故以乾物重診斷較佳，其暫定基準為90 mg/100 g dry。由表三顯示番荔枝幼果就會發生果實黑點病且正常果與黑點病果之Ca含量就有顯著的差異，因此採樣幼果作為診斷基準更能早期就診斷出有否缺鈣，而即時採取對策防治，幼果Ca含量的暫定基準為70 mg/100g dry。

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An Investigation of the Causes of Black Speck Disease on Sugar Apple Fruits

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Abstract

The causes of the black speck disease fruits of sugar apples (*Annona squamosa* L.) were investigated in 1994, the preliminary data showed that the skin and pulp Ca contents were remarkably higher than that of black speck disease fruits. For further confirming the causes, young fruits and ripe fruits suffered from varied disease index were sampled for mineral and chemical composition analysis to detect the difference between normal and black speck disease fruits on Ca contents and establish the criterion for diagnosing the Ca nutrient level. Upon the soil Ca and leaf Ca contents from normal and black speck disease orchards were hard to tell whether Ca stress could induce black speck disease or not. The average Ca contents of normal young fruits and ripe fruits on fresh or dry weight basis in summer crop being 20.6 and 27.9, or 82.6 and 95.2 mg/100g were significantly superior to that of black speck disease fruits being 14.8 and 16.1, or 56.6 and 53.5 mg/100g, respectively. The skin Ca and pulp Ca contents on different disease index ripe fruits in winter crop did not remarkably different from each other, but had the tendency of the severe the disease, the less the Ca content. The disease was classified into A (disease area 75% over), B (50–75%), C (25–50%), D (12.5–25%), E (0.1–12.5%) and F (non), and which mean pulp Ca contents on fresh and dry weight basis were 12.7, 13.1, 11.2, 12.5, 14.4, 16.3 and 41.3, 41.3, 37.5, 42.4, 51.3, 56.4 mg/100g, while the mean skin contents were 19.8, 22.6, 22.7, 27.7, 28.8, 34.6 and 64.2, 74.2, 68.4, 83.2, 89.0, 99.6 mg/100g, respectively. It is obvious that the correlation between black speck disease and skin Ca content is higher than black speck disease with pulp Ca content, therefore the skin is recommended as the diagnosis part.

The tentative diagnosis criterion of Ca contents for young fruits is 70 mg/100g dry, for summer and winter fruit skin are 33 mg/100g fresh and 90 mg/100g dry. It means that the Ca concentrations below the criterion, Ca deficiency and black speck disease might be occurred.

Key words: Sugar apples, Black speck disease, Calcium deficiency.