# Excessive leaf abscission in the avocado cultivar 'Ryan'

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**ABSTRACT**

Premature and excessive leaf abscission has been reported to occur in the avocado cultivar 'Ryan'. As the factors contributing to this phenomenon are still unknown, a study was undertaken to investigate the causes of excessive leaf abscission in 'Ryan' and assess preventative measures. The pattern of spring and summer flush leaf abscission and the effect of tree nutrient status, reserve food levels, flowering and total leaf area on leaf abscission were investigated. Plant growth regulators, nitrogen, boron and kaolin were applied from March 2007 in an attempt to retard excessive leaf abscission. In 2007, spring and summer flush leaf abscission was higher for 'Ryan' than for 'Fuerte' and 'Hass', but significantly less than the previous season for 'Ryan'. Tree nutrient status, reserve carbohydrate levels, flowering and leaf area were not significantly related to leaf abscission. There is therefore a possibility that the combination of a number of external factors causing the tree to stress could contribute to leaf abscission. Although chemical treatments tended to retard leaf abscission, the effect was not significant, probably because leaf abscission was low during the 2007 season. There was also no significant effect on fruit set and retention. It would therefore be important to investigate the effect of chemical treatments during a season of high leaf abscission, in order to assess if these treatments could significantly reduce leaf drop in 'Ryan'.

## INTRODUCTION

Excessive leaf abscission during flowering time, as reported in the past by growers, was confirmed to occur for the avocado cultivar 'Ryan' (Roets *et al.*, 2007). Leaves dropped excessively and possibly prematurely from both the previous spring and summer flushes, starting from inflorescence development and peaking at full flowering. Premature and excessive leaf drop during winter time (inflorescence development to full bloom) result in decreased carbohydrate production during winter and lower tree carbohydrate levels (Wolstenholme, 2001). Lower levels of carbohydrates will have a negative effect on fruit set and early fruit development and subsequently result in lower yields (Scholefield *et al.*, 1985). In addition, a new flush emerges just after fruit set and competes with young developing fruit for the limited available carbohydrates, which further negatively impacts fruit set (Whiley *et al.*, 1988). It would therefore be important to prevent excessive and premature leaf abscission in order to improve fruit set and production.

Leaf abscission is a natural phenomenon and the leaf lifespan of any plant is dependent on its genotype (Thomas & Stoddart, 1980; Chabot & Hicks, 1982; Roberts *et al.*, 2002). Avocado trees have on average a short leaf lifespan of 9 to 10 months (Whiley *et al.*, 1988; Wolstenholme, 2001). However, under environmental stress conditions leaf abscission may be accelerated to result in premature and excessive leaf abscission (Woeste *et al.*, 1999; Taylor & Whitelaw, 2001). Environmental stress conditions that may accelerate leaf abscission include light-stress and photo-inhibition (Michaeli *et al.*, 2001; Öquist & Huner, 2003), water stress (Munné-Bosch & Alegre, 2004), nutrient stress (Thomas & Stoddart, 1980; Rabe, 1990) and diseases (Thomas & Stoddart, 1980).

Environmental stress factors accelerate leaf abscission by causing changes in the hormonal balance of the plant that favour leaf abscission. It is the balance between auxin and ethylene that is particularly important in influencing leaf abscission (Hall, 1952; Chatterjee & Leopold, 1965; Brown, 1997). A high auxin:ethylene-ratio prevents abscission, while a low auxin:ethylene-ratio enhances abscission. In most cases environmental stress factors accelerate leaf abscission by increasing endogenous ethylene levels (Brown, 1997).

In order to prevent excessive leaf abscission, it would firstly be important to ensure that trees are healthy and not subjected to excessive stress. Orchard management programmes must be adapted to ensure that trees are not exposed to nutrient imbalances, water shortages or diseases. Other horticultural tools exists that can be employed to prevent excessive leaf abscission. These include the use of plant growth regulators (PGR), especially those containing auxins and cytokinins. These PGRs may increase the auxin:ethylene-ratio of the plant and prevent abscission (Abeles & Rubinstein, 1964; Raviv & Reuveni, 1984). However, it is important to bear in mind that PGRs function in very limited concentration ranges. At low concentrations auxins are known to prevent abscission, whilst at high concentrations they promote abscission (Grossmann & Hansen, 2001). Reflective substances, such as kaolin, can also be used to protect the plant against excessive solar radiation, thereby reducing light stress and solar damage to leaves (Glenn *et al.*, 2001; 2002; Gindaba & Wand, 2005). However, application of PGRs and kaolin alone do not provide a solution to the problem and farm management practices, as discussed, must also be optimum to ensure optimal production and healthy trees.

Application of PGRs and kaolin during the 2006 season did not yield any significant results, possibly because application was done after leaf abscission was initiated (Roets *et al.*, 2007). Earlier applications must therefore be considered for the 2007 season.

During the 2006 season, which was characterized by excessive leaf abscission, no relationship between tree nutrient levels, starch reserve levels and leaf abscission could be found. There was also no evidence of the occurrence of diseases and water stress. It was also found that excessive flowering had a significant negative effect on leaf retention (Roets *et al.*, 2007). Climatic data was not included and thus the influence of climate was unknown.

This study again focused on the causes of leaf abscission in 'Ryan', taking into consideration the previous season's findings and findings from previous workers cited here. Chemical applications of PGRs, kaolin and fertilizers were repeated in an attempt to reduce excessive leaf abscission in 'Ryan', but the applications were made earlier than the previous season.

## MATERIALS AND METHODS

The trial was conducted on the farm Langspruit in the Hazyview area in the same blocks of 'Fuerte', 'Hass' and 'Ryan' that were used during the 2006 season. Since there was no difference in leaf abscission between the two 'Ryan' blocks used in the 2006 season, only one block of 'Ryan' was used during the 2007 season. All standard orchard management practices, such as fertilization, irrigation scheduling, pest, disease and weed control performed on the farm, were the same in all three blocks. The following experiments were conducted:

### Determination of the time and pattern of leaf abscission

For each cultivar sixteen trees were selected in a random block design and four branches were marked per tree (two on the eastern and two on the western side of each tree). The number of leaves for the 2006 spring and 2007 summer flushes on each branch was recorded at six phenological stages (**Table 1**).

### The relationship between tree nutrient status and leaf abscission

Leaf samples were collected according to the method described by Koen and Du Plessis (1991) from the same selected trees as above. Sampling was done on the same phenological stages mentioned above. Leaves were analyzed for N, P, K, Ca, Mg, Zn, Cu, Mn, Fe and B by the soil science laboratory of the ARC-ITSC.

### The relationship between tree reserve food levels and leaf abscission

Bark discs were taken from the scaffold branches of the selected trees for each cultivar by using a 25 mm bell punch. The bark discs were oven dried for 72 hours at 60°C and ground through a 0.5 mm sieve. Starch content was then determined using the modified enzyme-chromogen method of Davie (1997).

### The relationship between flowering and leaf abscission

During flowering time, the number of flowers per inflo-

**Table 1. Phenological stages for data collection on three avocado cultivars**

| Phenological stage | Date |
|---|---|
| Bud dormancy | End-April to mid-June 2007 |
| Bud swell | Mid-June to mid-July 2007 |
| Inflorescence development | Mid-July to end-August 2007 |
| Full bloom | End-August to end-September 2007 |
| Fruit set | Mid-October 2007 |
| 4 weeks after fruit set | Mid-November 2007 |

**Table 2. Treatments applied for prevention of excessive leaf abscission for 'Ryan'**

| Chemical and concentration | Application time |
|---|---|
| Control | March 2007 |
| A combination of 150 g LAN, 100 g Solubor®, 5 mL/L Kelpak® soil application, and 3% Kaolin foliar application | LAN, Solubor® and Kelpak® – March and repeated in April 2007. Kaolin – monthly from March to July 2007 |
| 5 mL/m² Nontox-Silica® soil application | March 2007 and repeated during inflorescence development |
| 2 mL/L Nontox-Silica® foliar application | March 2007 and repeated during inflorescence development |
| 75 mg/L ProGibb® | March 2007 and repeated in April 2007 |
| Inflorescence thinning (removed approximately 33% of inflorescence by hand pruning) | During inflorescence development |

rescence and the number of inflorescences per branch were recorded for each of the selected trees for each cultivar. In addition, flower nutrient levels were determined by sampling inflorescences from the selected trees and analysing the inflorescences for N, P, K, Ca, Mg, Zn, Cu, Mn, Fe and B content. The flower nutrient analysis was performed by the soil science laboratory of the ARC-ITSC.

### The relationship between total leaf area and spring flush leaf abscission

Five hundred leaves of each cultivar were sampled and the length, width and leaf area of each leaf determined. The relationship between the leaf area and the product of leaf width and length was then determined. Thereafter, for each of the selected trees, the length and width of every leaf on the marked branches were recorded before leaf abscission occurred (dormant bud stage). The leaf area was calculated for each leaf using the relationship obtained between leaf area and the product of leaf width and length, where after the total leaf area for each branch was calculated.

### Chemical applications to retard excessive leaf abscission in 'Ryan'

Applications of plant growth regulators, fertilizers and kaolin were made on 'Ryan' trees in an attempt to retard excessive leaf abscission (**Table 2**). Applications were made, depending on the chemical used, either to the soil or as a full cover foliar spray. Treatments were applied from March until July 2007. A randomized block design was used. Leaf abscission and fruit set were recorded.

## RESULTS AND DISCUSSION

### Determination of the time and pattern of leaf abscission

For all the cultivars the mean percentage leaf abscission was calculated between consecutive phenological stages and analysis of variance was used to compare the cultivars with regard to leaf abscission between consecutive phenological stages (**Table 3** and **5**), and to compare the consecutive phenological stages within each cultivar (**Table 4** and **6**).

Between bud dormancy and inflorescence development there was no significant difference in the rate of leaf abscission between the cultivars for the spring flush (**Table 3**). Between inflorescence development and full bloom, 'Ryan' abscised significantly more spring flush leaves than the other cultivars. 'Hass' dropped significantly more leaves between fruit set and four weeks after fruit set than 'Fuerte' and 'Ryan' (**Table 3**). Within cultivars, both 'Fuerte' and 'Hass' showed a significantly higher rate of leaf abscission from full bloom till four weeks after fruit set (**Table 4**). The highest rate of leaf drop occurred on 'Ryan' trees between full bloom and fruit set (**Table 4**). Overall, total leaf abscission of the spring flush was the highest for 'Ryan', followed by 'Hass', and 'Fuerte' which displayed the lowest total leaf abscission (**Figure 1**).

For the summer flush 'Ryan' displayed higher leaf abscission than 'Fuerte' and 'Hass' between inflorescence development and fruit set (**Table 5**). This cor-

**Table 3. Comparison of the rate of spring flush leaf abscission between three avocado cultivars within consecutive phenological stages**

| Phenological stage | Fuerte | | Hass | | Ryan | |
|---|---|---|---|---|---|---|
| | Mean % leaf abscission[#] | STD | Mean % leaf abscission[#] | STD | Mean % leaf abscission[#] | STD |
| Bud dormancy to bud swell | 4.96a | 6.15 | 3.88a | 5.33 | 7.59a | 15.11 |
| Bud swell to inflorescence development | 1.44a | 2.69 | 1.74a | 4.92 | 5.42a | 12.56 |
| Inflorescence development to full bloom | 0.77b | 2.01 | 0.74b | 2.45 | 15.35a | 24.81 |
| Full bloom to fruit set | 10.87a | 11.68 | 17.84a | 16.85 | 26.13a | 30.62 |
| Fruit set to 4 weeks after fruit set | 11.55b | 14.10 | 24.84a | 20.34 | 11.35b | 18.81 |

[#]Means in the same column followed by the same letter do not differ significantly at P = 0.05

**Table 4. Comparison of the rate of spring flush leaf abscission between consecutive phenological stages for three avocado cultivars**

| Phenological stage | Fuerte | | Hass | | Ryan | |
|---|---|---|---|---|---|---|
| | Mean % leaf abscission[#] | STD | Mean % leaf abscission[#] | STD | Mean % leaf abscission[#] | STD |
| Bud dormancy to bud swell | 4.96ab | 6.15 | 3.88b | 5.33 | 7.59ab | 15.11 |
| Bud swell to inflorescence development | 1.44b | 2.69 | 1.74b | 4.92 | 5.42b | 12.56 |
| Inflorescence development to full bloom | 0.77b | 2.01 | 0.74b | 2.45 | 15.35ab | 24.81 |
| Full bloom to fruit set | 10.87a | 11.68 | 17.84a | 16.85 | 26.13a | 30.62 |
| Fruit set to 4 weeks after fruit set | 11.55a | 14.10 | 24.84a | 20.34 | 11.35ab | 18.81 |

[#]Means in the same column followed by the same letter do not differ significantly at P = 0.05

responded with the data of the previous year's summer flush for 'Ryan' (Roets *et al.*, 2007). However, between consecutive phenological stages within each cultivar, there were no significant differences (**Table 6**). Overall, 'Ryan' showed higher leaf abscission for the summer flush than the other two cultivars (**Figure 2**). Leaf abscission of the summer flush for 'Ryan' during the 2007 season was highly significantly lower than the previous season, indicating that excessive leaf abscission as observed during the 2006 season did not occur in the 2007 season (data not shown). Higher summer flush leaf abscission for 'Ryan' might possibly be the result of this cultivar being more sensitive to external stress factors causing leaf abscission, than the other cultivars.

Spring flush leaf abscission was overall significantly higher than summer flush leaf abscission for all cultivars during the 2007 season (**Figure 1** and **2**). During the 2006 season, spring flush leaf abscission was also significantly higher than summer flush leaf abscission for all the cultivars (Roets *et al.*, 2007). Higher abscission of the spring flush leaves could possibly be attributed to natural ageing, as these leaves at the time of abscission reached the average lifespan of avocado leaves as described by Wolstenholme (2001). Abscission of old spring flush leaves at the end of their lifespan will be to the tree's advantage as old leaves cost the tree in terms of carbohydrates, nutrients and water (Munné-Bosch & Alegre, 2004; Heath *et al.*, 2005). In addition, these old leaves also contain valuable nutrients that are redistributed to younger, more active plant organs where needed (Mengel & Kirkby, 1978; Thomas

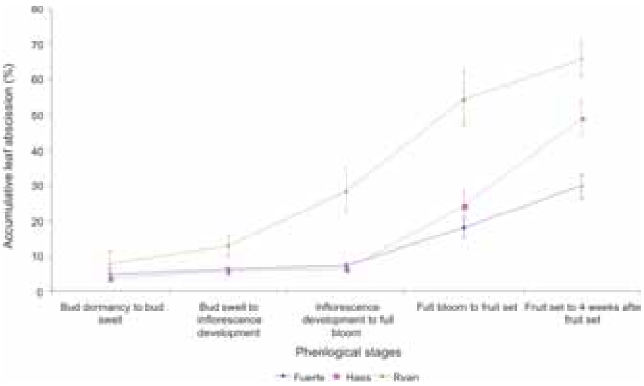


**Figure 1. Spring flush leaf abscission pattern for three avocado cultivars**

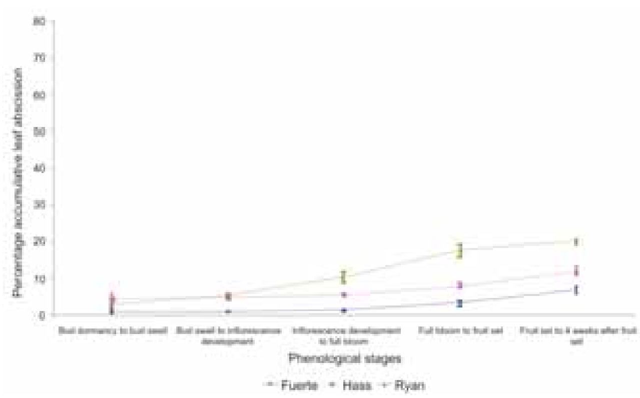


**Figure 2. Summer flush leaf abscission pattern for three avocado cultivars**

**Table 5. Comparison of the rate of summer flush leaf abscission between three avocado cultivars within consecutive phenological stages**

| Phenological stage | Fuerte | | Hass | | Ryan | |
|---|---|---|---|---|---|---|
| | Mean % leaf abscission# | STD | Mean % leaf abscission# | STD | Mean % leaf abscission# | STD |
| Bud dormancy to bud swell | 1.01b | 2.30 | 4.35a | 5.94 | 2.96ab | 5.86 |
| Bud swell to inflorescence development | 0.00b | 0.00 | 0.36ab | 1.00 | 2.19a | 3.01 |
| Inflorescence development to full bloom | 0.23b | 0.93 | 0.71b | 1.29 | 5.10a | 6.20 |
| Full bloom to fruit set | 1.88b | 3.17 | 2.47b | 2.59 | 7.15a | 6.88 |
| Fruit set to 4 weeks after fruit set | 3.76a | 3.96 | 3.83a | 4.86 | 2.60a | 3.14 |

#Means in the same column followed by the same letter do not differ significantly at P = 0.05

**Table 6. Comparison of summer flush leaf abscission between different phenological stages for three avocado cultivars**

| Phenological stage | Fuerte | | Hass | | Ryan | |
|---|---|---|---|---|---|---|
| | Mean % leaf abscission# | STD | Mean % leaf abscission# | STD | Mean % leaf abscission# | STD |
| Bud dormancy to bud swell | 1.01ab | 2.30 | 4.35a | 5.94 | 2.96a | 5.86 |
| Bud swell to inflorescence development | 0.00b | 0.00 | 0.36a | 1.00 | 2.19a | 3.01 |
| Inflorescence development to full bloom | 0.23ab | 0.93 | 0.71a | 1.29 | 5.10a | 6.20 |
| Full bloom to fruit set | 1.88ab | 3.17 | 2.47a | 2.59 | 7.15a | 6.88 |
| Fruit set to 4 weeks after fruit set | 3.76a | 3.96 | 3.83a | 4.86 | 2.60a | 3.14 |

#Means in the same column followed by the same letter do not differ significantly at P = 0.05

& Stoddart, 1980; Aerts, 1996). However, external factors could also have a minor influence on spring flush leaf abscission, since leaf abscission differed between cultivars (**Figure 1**).

### The relationship between tree nutrient status and leaf abscission

No significant effect of tree nutrient levels on leaf abscission at the bud dormancy stage could be observed with analysis of variance. Copper and B levels correlated significantly at bud break, although not very strongly with leaf abscission during bud swell and inflorescence development for 'Ryan' (r=0.575 and P=0.0198 for Cu; and r=0.662 and P=0.005 for B). This indicated that these two nutrients contributed to leaf abscission in 'Ryan' during bud swell and inflorescence development. Both nutrients were outside the recommended optimal ranges (SAAGA Research and Technical Committee, 1990), with boron below the optimal ranges (33.1 ppm, with the optimal range between 50 and 80 ppm) and copper far above the optimal range (195 ppm, with the optimal range lying between 5 and 15 ppm). All other nutrients were within their optimal ranges (data not shown). Apart from a contribution to excessive leaf abscission, nutrient imbalances will also have a negative effect on tree performance, yield and development (Rashid & Ryan, 2004). It is therefore crucial to ensure that tree nutrients levels are within the optimal ranges to prevent stress that can result in excessive leaf abscission.

### The relationship between tree reserve food levels and leaf abscission

Analysis of variance showed no significant effect of starch reserve levels at bud dormancy on leaf abscission for any of the cultivars. In addition, there was also net accumulation of starch reserves throughout the winter (from bud dormancy till fruit set) for all cultivars (**Figure 3**), implying that leaves were productive during winter, producing enough carbohydrates for flowering, fruit set and storage. It was only after fruit set that net carbohydrate usage was observed (**Figure 3**), possibly because developing fruit needed more carbohydrates than what could be produced by current photosynthesis. In addition, the new spring flush also emerged at that time which would require additional carbohydrates.

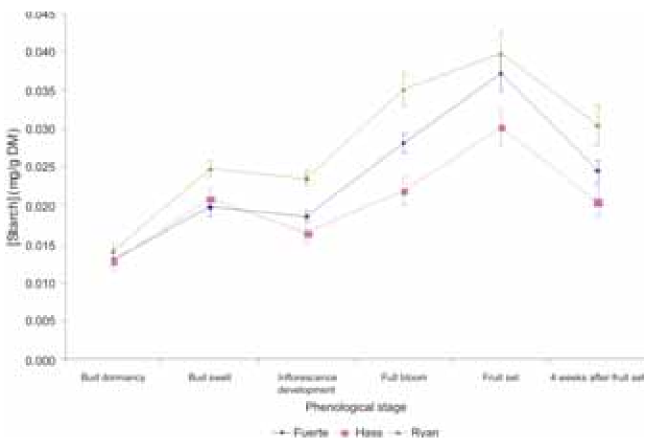


**Figure 3. Changes in bark carbohydrate levels over time for three avocado cultivars**

### The relationship between flowering and leaf abscission

Kruskal-Wallis tests were performed to test whether i) the number of flowers per inflorescence, and ii) the number of inflorescences per branch differed significantly for the three avocado cultivars. Hass had significantly more flowers per inflorescence than 'Fuerte' and 'Ryan', but 'Ryan' had about four times more inflorescences per branch than 'Fuerte' and 'Hass' (**Table 7**). 'Ryan' therefore produced more flowers than the other two cultivars. However, no relationship between flowering and leaf abscission could be observed for the 2007 season (**Table 7**). During the 2006 season 'Ryan' flowered significantly more than during the 2007 season (6.61 inflorescences per branch during the 2006 season, in comparison with 2.29 inflorescences per branch during the 2007 season) and as a result a significant relationship was found between flowering and leaf abscission during the 2006 season (Roets *et al.*, 2007). It is possible that excessive flowering in 'Ryan' might be a result of stress. The relationship between flowering and leaf abscission found during the 2006 season, might indicate that the same factors causing excessive leaf abscission (possibly stress) also causes heavier flowering. This is possible because stress usually elevates endogenous ethylene levels, and apart from causing leaf abscission, ethylene may also stimulate heavier flowering (Taiz & Zeiger, 2006). Heavy flowering may also impose additional stress on the plant, which may enhance leaf abscission and in turn could possibly contribute to the correlation between flowering and leaf abscission as it was found during the 2006 season.

Kruskal-Wallis tests were done to compare flower nutrient levels for the three cultivars. Similar results for the 2006 and 2007 seasons were found with many of the macro- and micronutrients in 'Ryan' flowers occurring in higher quantities than in 'Fuerte' and 'Hass' flowers (**Table 8**). For both seasons 'Ryan' flowered

**Table 7. Flowering for three avocado cultivars and their correlation with leaf abscission**

| Cultivar | Number of flowers per inflorescence | | Number of inflorescences per branch | | Correlation coefficient (r)* |
|---|---|---|---|---|---|
| | Mean# | STD | Mean | STD | |
| Fuerte | 168b | 31.08 | 0.86b | 0.71 | 0.468 |
| Hass | 214a | 45.11 | 0.94b | 0.51 | -0.328 |
| Ryan | 140b | 36.59 | 2.29a | 1.08 | 0.189 |

#Means in the same column followed by the same letter do not differ significantly at P = 0.05
*Correlations were not significant at P = 0.05 for all cultivars

heavier than the other two cultivars. This implies that 'Ryan' trees have a higher demand for nutrients during flowering time than 'Fuerte' and 'Hass', because of its higher production of flowers. It would therefore be recommended that fertilizer programs be adapted in order to provide the tree with needed nutrients during flowering time.

### The relationship between total leaf area and spring flush leaf abscission

For all cultivars strong linear correlations were found between leaf area and the product of leaf length and width (**Figure 4** to **6**). Therefore, by obtaining the length and the width of an avocado leaf, leaf area can be calculated by applying the linear equations for leaf area and the product of the leaf length and width. The formulae in **Figure 4** to **6** were used to determine the total leaf area for each branch as described in the Materials and Methods. Kruskal-Wallis tests were performed to test if there were any significant differences in total leaf area per branch between the cultivars. Correlations between leaf area and leaf abscission were also assessed.

Although the total leaf area for 'Ryan' was significantly less than for 'Hass' (**Table 9**), none of the cultivars showed any significant relationship between leaf area and spring leaf abscission **(Table 9**). Heath *et al.* (2005) found that a relationship exists between leaf abscission of the flush prior to the most recent flush (which would be the spring flush for this study) and the total leaf area of the branch. They found that if the total leaf area on the branch is equal or higher than 1 000 cm$^2$, no leaf abscission will occur, suggesting that the assimilatory support is high enough to prevent leaf abscission. This therefore implies that leaf abscission may also be influenced by the total productivity of the leaves on a branch. In this study very weak correlations were found between total leaf area and spring flush leaf abscission, suggesting that the impact of other stress factors on leaf abscission may be more influential than the total productivity of leaves on the

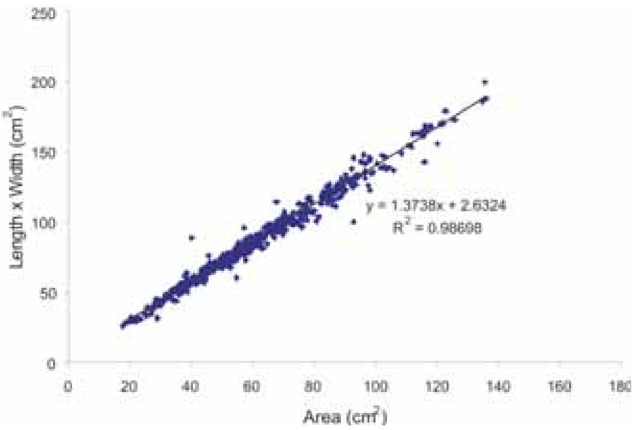


**Figure 4. The relationship between leaf area and the product of leaf width and length for 'Fuerte'**

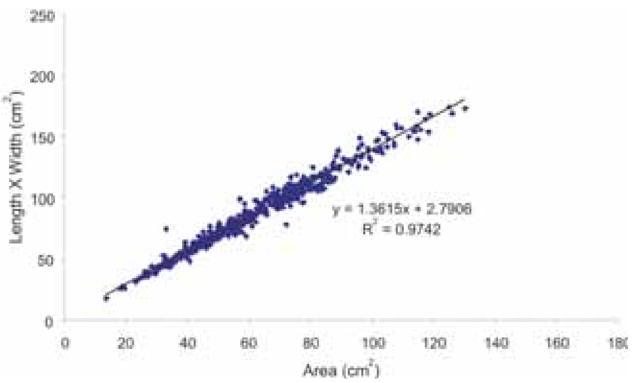


**Figure 5. The relationship between leaf area and the product of leaf width and length for 'Hass'**

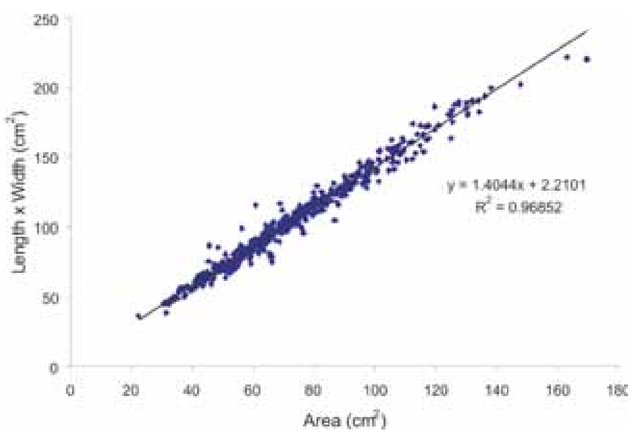


**Figure 6. The relationship between leaf area and the product of leaf width and length for 'Ryan'**

**Table 8. Nutrient levels of flowers at full bloom for three avocado cultivars**

| Nutrient | Fuerte | | Hass | | Ryan | |
|---|---|---|---|---|---|---|
| | Mean# | STD | Mean | STD | Mean | STD |
| N (%) | 1.37b | 0.111 | 2.24a | 0.313 | 2.38a | 0.348 |
| P (%) | 0.20b | 0.016 | 0.24b | 0.025 | 0.30a | 0.036 |
| K (%) | 1.71a | 0.127 | 1.57b | 0.119 | 1.64ab | 0.166 |
| Ca (%) | 0.37ab | 0.054 | 0.32b | 0.047 | 0.38a | 0.064 |
| Mg (%) | 0.31b | 0.030 | 0.27b | 0.029 | 0.38a | 0.019 |
| Zn (mg/kg) | 24.76b | 3.95 | 27.60b | 5.40 | 42.88a | 4.77 |
| Cu (mg/kg) | 22.50a | 8.71 | 14.73b | 2.81 | 20.44a | 4.19 |
| Mn (mg/kg) | 50.00b | 9.45 | 103.47a | 64.85 | 87.50a | 33.65 |
| Fe (mg/kg) | 92.57a | 14.70 | 83.93a | 11.59 | 55.06b | 5.81 |
| B (mg/kg) | 33.88b | 4.45 | 32.20b | 6.35 | 47.39a | 7.91 |

#Means in the same column followed by the same letter do not differ significantly at P = 0.05

branch. However, during 2007 leaf abscission was very low, and it is possible that the correlations obtained for the 2007 season (low leaf abscission) may differ from a season with high leaf abscission.

### Chemical applications to retard excessive leaf abscission in 'Ryan'

Although chemical applications tended to improve leaf retention, analysis of variance showed that none of the treatments had any significant improvement in leaf retention of 'Ryan' (**Table 10**). There was also no significant effect of these treatments on fruit set or fruit retention after the November fruit drop period (**Table 11**). The lack of a significant effect of these treatments on leaf abscission during the 2007 season may be attributed to the low overall rate of leaf abscission observed during this season. However, taking into consideration that none of the treatments had any significant effect on fruit set and retention, it might indicate that the application time or concentrations were not optimal. Further investigations into the correct time and application rates of chemicals are therefore needed.

### SUMMARY

Excessive leaf abscission, as reported by growers, was found to occur for the avocado cultivar 'Ryan' during the 2006 season. Investigations done on leaf abscission during the 2007 season showed that excessive leaf abscission did not occur for 'Ryan' during that specific season and it can be concluded that excessive and premature leaf abscission for 'Ryan' occur during certain seasons only and is possibly triggered by external factors that result in stress of trees with the subsequent reaction of leaf abscission. Possible stress factors that can result in premature leaf abscission include climatic stress (light stress), drought, nutrient imbalances and diseases. Climatic stress (light and temperature) was investigated and compared for the 2006 and 2007 sea-

**Table 9. Leaf areas and their correlations with spring flush leaf abscission for three avocado cultivars**

| Cultivar | Total leaf area ($cm^2$) per branch | | Correlations with spring flush leaf abscission ($r^2$)* |
|---|---|---|---|
| | Mean total leaf area ($cm^2$) | STD | |
| Fuerte | 713ab# | 187.6 | 0.0221 |
| Hass | 713a | 126.9 | 0.0068 |
| Ryan | 599b | 127.8 | 0.0017 |

#Means followed by the same letter do not differ significantly at P=0.05
*Correlations were not significant at P=0.05 for all cultivars

**Table 10. Effect of chemical applications on leaf abscission of 'Ryan'**

| Treatment | Percentage leaf abscission | |
|---|---|---|
| | Mean# | STD |
| Control | 29.61a | 22.17 |
| 150 g LAN, 100 g Solubor®, 5 mL/L Kelpak® & 3% Kaolin (March, April and May 2007) | 24.10a | 14.78 |
| 5 mL/m2 Nontox-Silica – soil application (Bud dormancy & Inflorescence development) | 22.61a | 13.37 |
| 2 mL/L Nontox-silica – foliar application (Bud dormancy & Inflorescence development) | 18.79a | 13.06 |
| 75 mg/L ProGibb – foliar application (Bud dormancy & bud break) | 22.01a | 12.07 |
| Inflorescence thinning (Inflorescence development) | 23.12a | 17.58 |

#Means followed by the same letter do not differ significantly at P = 0.05

**Table 11. Effect of chemical applications on fruit set and retention of 'Ryan'**

| Treatment | Mean number of fruit set per branch | | Mean number of fruit per tree after the November fruit drop period | |
|---|---|---|---|---|
| | Mean# | STD | Mean# | STD |
| Control | 0.50a | 0.76 | 44a | 46.7 |
| 150 g LAN, 100 g Solubor®, 5 mL/L Kelpak® & 3% Kaolin (March, April and May 2007) | 1.65a | 2.12 | 52a | 47.6 |
| 5 mL/m2 Nontox-Silica – soil application (Bud dormancy & inflorescence development) | 0.69a | 0.67 | 53a | 31.4 |
| 2 mL/L Nontox-silica – foliar application (Bud dormancy & inflorescence development) | 1.93a | 2.07 | 72a | 58.2 |
| 75 mg/L ProGibb – foliar application (Bud dormancy & bud break) | 0.70a | 1.48 | 37a | 46.4 |
| Inflorescence thinning (Inflorescence development) | 0.48a | 0.69 | 36a | 27.2 |

#Means followed by the same letter do not differ significantly at P = 0.05

son with no differences obtained between the ratio of temperature to solar radiation. There was, however, a trend that the change for photo-inhibition during the 2006 season was greater than during the 2007 season and climate could play a role in premature leaf abscission in 'Ryan'. Nutrient levels did not correlate with leaf abscission. Effective control of Phytophthora by means of stem injections of Aliette® makes it highly unlikely that this disease could be a contributing factor to excessive leaf abscission. Rainfall was higher during the 2006 season than during the 2007 season that also makes it highly unlikely that drought stress could result in excessive leaf abscission in 'Ryan'. No correlation between carbohydrate reserve levels and leaf abscission was found and it also appear if reserve carbohydrate levels are negatively affected only during seasons of high leaf abscission at flowering time when flowering is excessive. This may deplete carbohydrate reserves and result in lower fruit set and retention. As excessive flowering correlated significantly with leaf abscission during the 2006 season, it should be prevented. Applications of plant growth regulators and extra fertilizer applications did not yield any significant results and should be investigated further, possibly as part of an integrated overall management program.

## CONCLUSION

Excessive leaf abscission, as was found for the 2006 season, did not occur for the cultivar 'Ryan' during the 2007 season, but 'Ryan' still abscised more leaves than 'Fuerte' and 'Hass'. Since the relationship of leaf abscission with tree nutrient status, reserve food levels, flowering and total leaf area was not significant, it could either indicate that i) a single external factor, as investigated in this study, did not have an effect on leaf abscission, and the combination of a number of external factors needs to be considered, or ii) other external factors, such as climate, which must be studied over a longer period, may play a major role in excessive leaf abscission in 'Ryan'. Although the application of PGRs and kaolin had no significant improvement in leaf retention and fruit set and retention in the 2007 season, further studies should be undertaken to ascertain whether, in combination with a good orchard management program, leaf retention and fruit set in 'Ryan' could perhaps be improved.


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