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UNDERSTANDING AVOCADO FRUIT SET IN NEW ZEALAND – AN OVERVIEW

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SUMMARY

Under New Zealand conditions daily temperatures during spring appear to have only a minor role in fruit set. Of most importance has been soil moisture content in the spring of each year with mineral nutrition exerting a general effect on fruit set. Pollination is not a problem area as large numbers of fruit are set but are then dropped in excessive numbers. As yet it is not known what may be setting the crop level from year to year. We have determined that several factors are not important for fruit set but we have only identified one major factor as critical to fruit set. One other factor that may be critical for fruit set according to the scientific literature is carbohydrate reserves (starch) within the tree at flowering. Our research programme over the next few years will concentrate on understanding the role starch levels in the tree play in determining the amount of fruit set for well managed trees with adequate water supply and mineral nutrition.

Key words: weather, temperature, soil moisture, flowering, fruit drop, yield

INTRODUCTION

The avocado crops harvested during 2003 and 2004 in New Zealand were much lower than expected and are remembered as years in which fruit set failed for many orchards. The reasons for this fruit set failure were poorly understood and prompted considerable research activity by the AIC. The goal of this research has been to improve our understanding of what factors most influence setting a new crop of avocados. In particular what were the reasons for the poor fruit sets in the springs of 2002 and 2003? In 2003 the author presented a seminar that gave an overview of avocado fruit set under New Zealand conditions that was based on a review of overseas literature and what limited data was available. This report takes the new information collected since 2003 to update and further analyse weather data and the physiological changes observed during flowering and fruit set. A summary of what is happening during flowering and fruit set under New Zealand conditions is presented along with the direction future fruit set research may be taken by the New Zealand Avocado Growers' Association.

EVENTS LEADING TO FRUIT SET

In New Zealand avocado inflorescences set large numbers of fruit over flowering of which very few (<1%) typically survive to harvest. Poor pollination success is not considered to be the reason for fruit set failure in New Zealand orchards as pinhead or match head sized fruit are always present before an excessive fruit drop.

Figure 1. Fruit set on a typical inflorescence at the end of flower opening (left) and four months later (right) following the December and March fruit drop.

Understanding the fruit set process is important to determine what steps in creating a new fruit may be affected that lead to fruit abscission. The steps in the process are described in detail in the NZ Avocado Growers' Association Growers' Manual (DIXON, 2004).

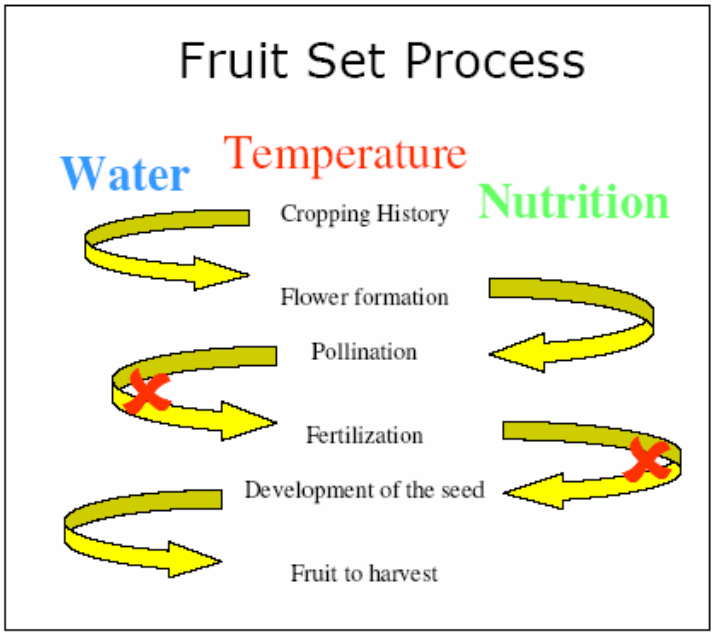

Figure 2. A schematic representation of the steps in the fruit set process.

In brief: the cropping history of the trees determines the amount of flowering, pollination is the physical transfer of pollen from one flower to the next and the growth of the pollen tube within the flower, fertilisation is the formation of the embryo and the first step in developing a seed, the seed grows along with the rest of the fruit.

At the fertilisation, seed development and fruit growth stages the fruit is susceptible to abscission. According to a survey of the scientific literature on avocado fruit set there appeared to be three main factors that could be responsible for poor fruit set. The factors are: cold temperatures, water stress and nutrient imbalance.

DOES THE WEATHER AFFECT FRUIT SET?

If temperature and water stress affect fruit set then it would be expected that the weather would have a large influence on fruit set success. The main weather events worth examining would be cold and warm periods during the spring months of September, October and November and soil moisture deficit over the same months.

TEMPERATURE

To determine the effect of daily changes in temperature the number of flowers open and numbers of fruit present were counted every 3 or 4 days on five trees from the beginning of flowering (November 2004) until after the first fruit drop at the end of December 2004 (Figure 3). Temperature loggers recorded the air temperature every 30 minutes during the same period.

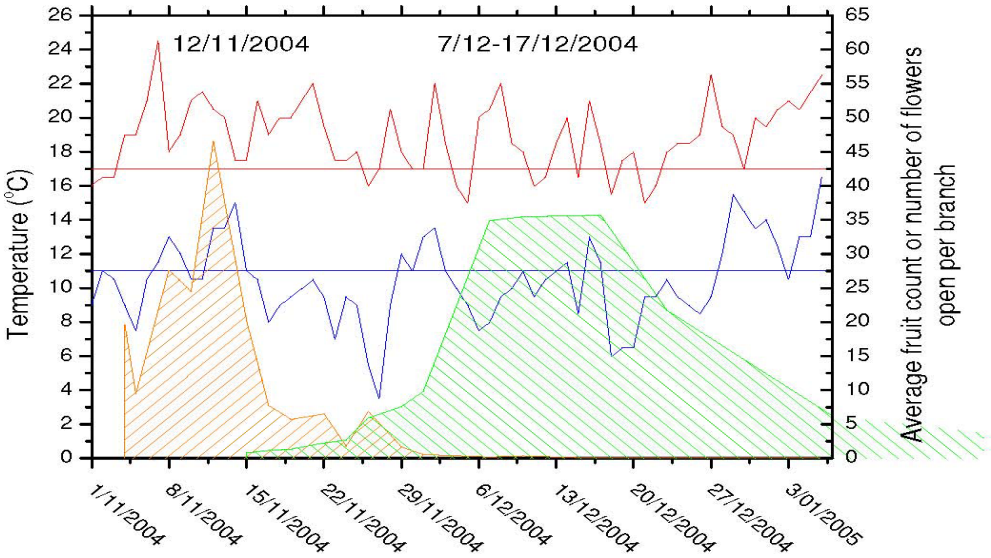

Figure 3. Pattern of flower opening and fruit set of Hass avocados during spring 2004. Key: orange striped area – number of open flowers; green striped area – number of fruit; red line - daily maximum temperature; blue line - daily minimum temperature.

Changes in the numbers of open flowers were closely related to changes in daily maximum and minimum temperatures with flower opening peaking after a prolonged period of warm days. Fruit numbers increased to reach a maximum about one month

after the peak of flowering after which fruit number declined. The timing of the fruit drop at about one month after the peak of flowering was a consistent pattern we observed on several orchards. Cold temperatures about one month after flowering have been blamed for excessive fruit drop by some in the avocado industry in New Zealand. The pattern of change in fruit number in Figure 3 and the simultaneous fruit drop over several orchards would suggest that the weather at this time may only be co-incidental to fruit drop. Low night temperatures have also been considered to induce fruit drop. On November 28 there was a minimum temperature of below 4°C but fruit number continued to increase. Such results would suggest that periods of low temperatures after flowering are not a major cause of fruit drop.

The Freshco Comparative Orchard program has been monitoring orchard temperatures of more than 40 orchards since 2002. The average daily maximum and minimum temperatures in October and November for the springs of 2002 to 2004 do not correlate well with the total crop harvested in the following year (Table 1). The two orchards listed in Table 1 are representative of the approximately 40 orchards in the Freshco Comparative Orchard programme.

		October			November	
Orchard	Year	Max	Min	Yield t/ha	Max	Min
A	2002	18.8	7.7	23.9	20.1	10.1
	2003	18.2	9.0	15.4	20.6	10.1
	2004	17.7	10.2	20.9est	20.3	10.7
B	2002	19.0	7.9	5.4	21.1	10.1
	2003	17.8	9.7	5.2	20.6	10.3
	2004	17.8	10.6	7.4est	19.8	11.0

Table 1. Average daily maximum and minimum temperatures and yield during October and November in the years 2002 to 2004 for two orchards in the mid north region of New Zealand. est = estimate.

Average temperatures may not reflect accurately the pattern of temperature changes or indicate periods of low temperatures interspersed with warm spells that have been claimed to be responsible for inducing excessive fruit drop. Summing the number hours below 11°C in December, the month when the fruit drop typically occurs, would be expected to indicate periods of cold temperatures. If cold temperatures are affect fruit drop then the greater the number of hours below 11°C the lower the yield.

The number of hours below 11°C was poorly correlated with yield clearly showing that periods of cold temperatures are not the main reason for fruit drop. In fact, no matter how temperature was expressed there was no readily discernable pattern of decreased yield in relation to cold temperatures.

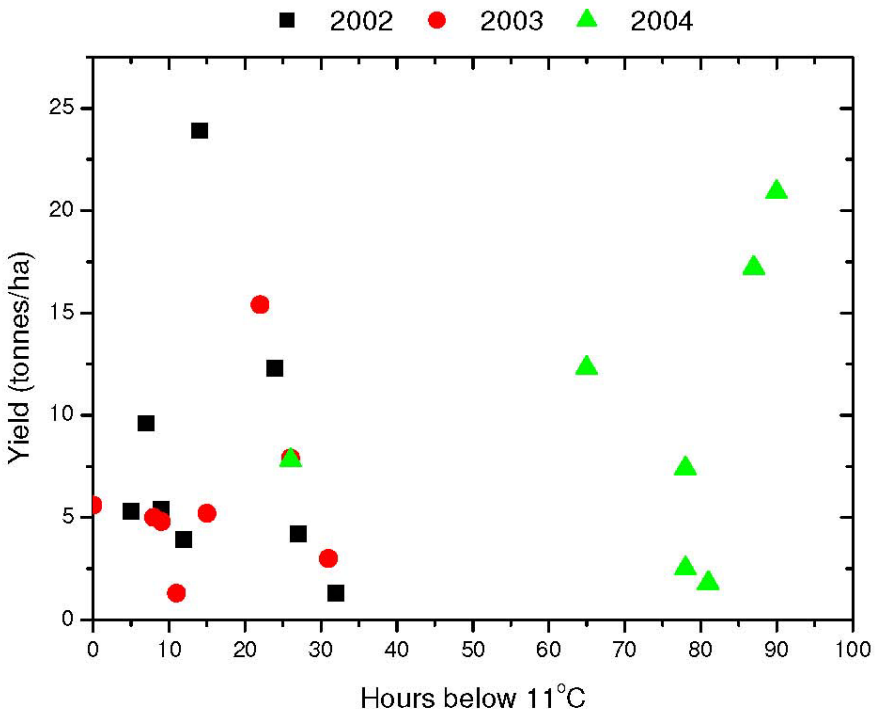

Figure 4. Relationship between yield and number of hours below 11°C in December for eight orchards in the years 2002 to 2004.

WATER

If cold temperatures are not the cause of excessive fruit drop but the weather is having an effect on yield what other aspect of the weather could be having a major impact? The amount of rain each spring may be an important influence on fruit set as avocado trees demand for water increases over the flowering period. Frequent rain would be expected to maintain soil moisture levels mitigating water stress on the trees. Few avocado orchards in New Zealand monitor their soil moisture during flowering and fruit set. The National Institute for Water and Atmospheric research (NIWA) maintains weather stations across New Zealand and publishes monthly summaries of soil moisture availability. The average percentage soil moisture levels for the main avocado flowering and fruit set period (November) for the Bay of Plenty and Far North regions were compared to the total crop in the following year (Figure 5). The Bay of Plenty region avocado orchards are largely un-irrigated; the Far North region avocado orchards are all irrigated. There has been considerable difference in soil moisture availability each November during the years 2001 to 2004. In 2001 soil moisture availability was very much greater than in the following years with 2002 November being very dry at only 12.5% and 25% of available soil moisture for the Bay of Plenty and Far North, respectively. Low soil moisture availability correlated well with the drop in total crop from the Bay of Plenty region despite large increases in bearing acreage. By contrast the total crop in the Far North region was maintained and has continued to

increase in line with increases in acreage. A lack of irrigation to manage soil moisture deficit in the Bay of Plenty appears to have been the most likely reason responsible for poor crops. As each November in subsequent years has had greater soil moisture availability so has the total crop continued to increase but the crop has not increased as much as expected as there have been large increases in additional acreage.

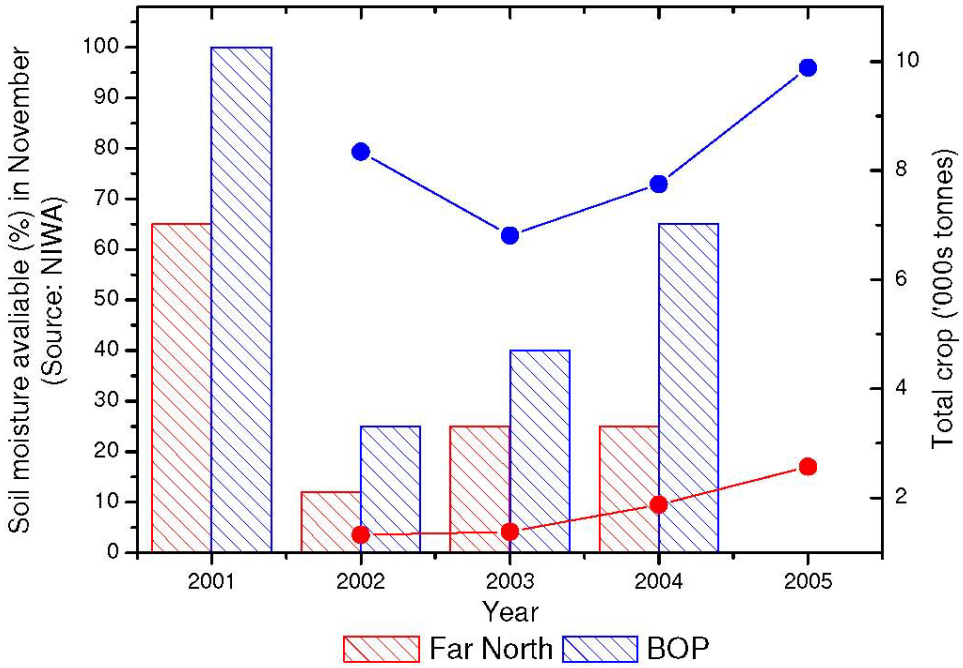

Figure 5. Relationship between average soil moisture availability in the main flowering and fruit set period for the years 2001 to 2004 and total crop the following year. The 2005 crop values are taken from the 2005 AIC crop estimate.

In Figure 5 yield and available soil moisture was averaged across regions and showed a clear impact of reduced soil moisture on yield. Therefore, individual orchards should show a clear relationship between soil moisture deficit in November and yield. In the spring of 2004 we monitored soil moisture at 30 cm using tensiometers and counted fruit numbers on five orchards in the Bay of Plenty. There was a very clear relationship between soil moisture deficit and fruit number before the first drop where the greater the soil moisture deficit the lower the numbers of fruit (Figure 6). It is clear that soil moisture levels during flowering, fruit set and fruit drop has a significant effect on yield in Bay of Plenty orchards.

NUTRITION

Apart from soil moisture deficit what else could be affecting fruit set? The problem steps are in creation of the seed and in avoiding excessive fruit drop. We know that there can

be big differences in fruit numbers between well managed orchards where water stress has been avoided. Are such differences explained by different nutrition levels? It has been reported for many years that the fertilizer regime can affect yield. We investigated two important nutrition factors thought to affect fruit set: flower boron levels and leaf nitrogen percentage.

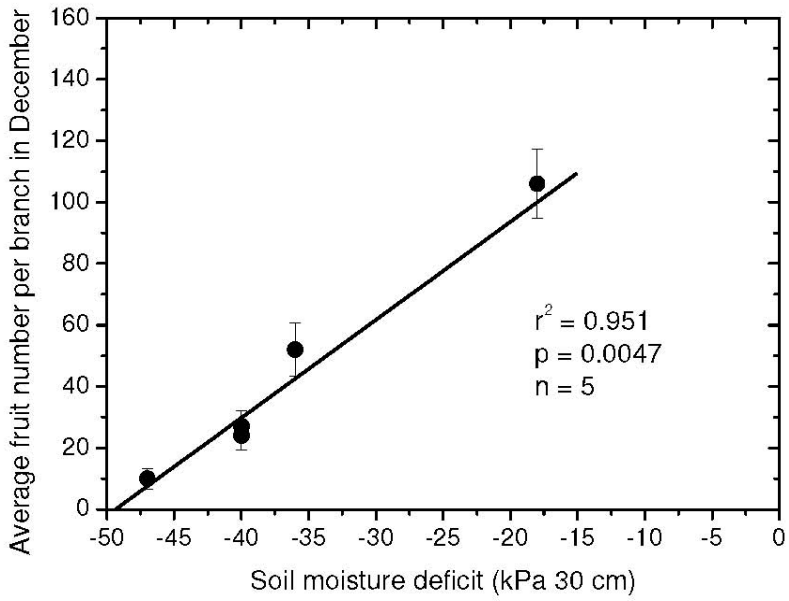

Figure 6. Relationship between soil moisture deficit in December 2004 and average fruit number per branch for five orchards in the Bay of Plenty region of New Zealand.

A trial was conducted where flower boron levels were increased through the use of foliar applications of Solubor in spring. Changes in boron concentrations in the inflorescences were related to fruit set with an optimum boron concentration of about 55-60ppm (Figure 7). While there was an effect on fruit set of increased flower boron concentration there were large differences in fruit set from orchard to orchard at the same boron concentrations (Figure 7). This would imply that boron is not an overriding factor in avocado fruit set under New Zealand conditions. Several New Zealand avocado growers have suggested that the fruit set failure in 2002 and 2003 was due to leaf nitrogen levels exceeding 2.7%. The effect on the tree would be to change the balance of the tree to favour vegetative growth over fruiting. However, leaf nitrogen levels from leaves sampled in April/May when related to yield shows only a general increasing trend with yield (Figure 8).

The results presented in Figures 7 and 8 suggest that mineral nutrients while important have a general influence on yield and that fruit set is affected more by other overriding factors.

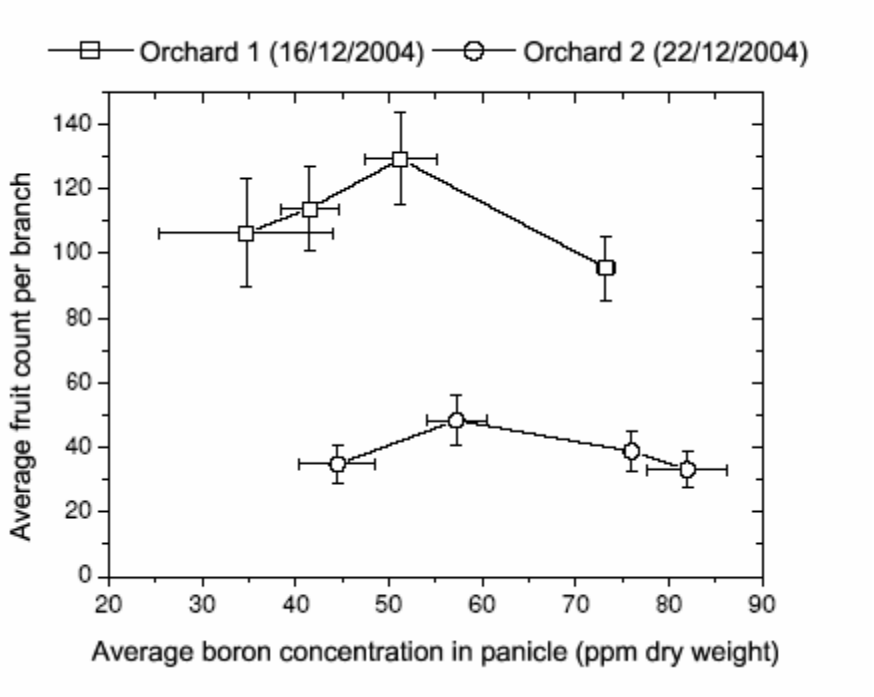

Figure 7. Relationship between inflorescence boron concentration and fruit set.

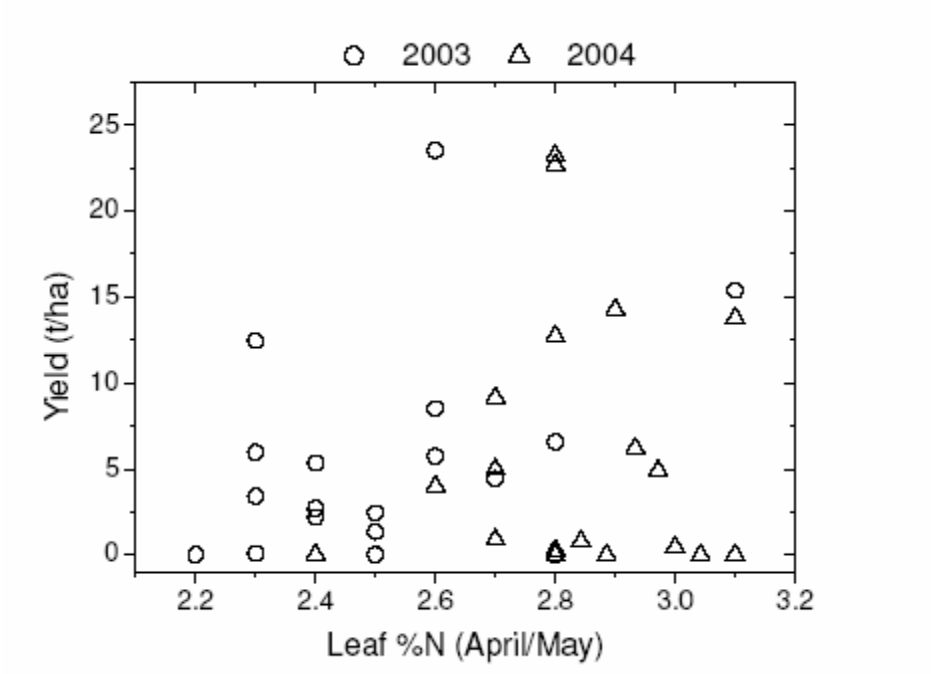

Figure 8. Relationship between percentage leaf nitrogen and yield.

FUTURE DIRECTIONS

Carbohydrate reserves in the form of starch have been associated with fruit set in South Africa and Australia (DAVIE et al, 1995; WOLSTENHOLME and WHILEY, 1997). High levels of starch at flowering have been suggested as critical to fruit set success and may be useful indicators of tree performance. Starch levels may be affected by tree growth patterns occurring during flowering, for example, competition between developing shoots and new fruit may affect fruit drop. Our research programme over the next few years will concentrate on understanding the role starch levels in the tree play in determining the amount of fruit set for well managed trees with adequate water supply and mineral nutrition.

CONCLUSIONS

Under New Zealand conditions daily temperatures during spring have a minor effect on fruit set. Of most importance is been soil moisture deficit with mineral nutrition exerting a general effect on fruit set. Pollination is not considered a problem as large numbers of fruit are set but are then dropped in excessive numbers. As yet, apart from rainfall from year to year, it is not known what may be setting the crop level from year to year in well managed orchards.

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