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A BETTER UNDERSTANDING OF ALTERNATE BEARING THROUGH REVISED GROWTH MODEL CHARTS

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Alternate bearing remains one of the major horticultural challenges in the management of avocado orchards. It also presents marketing and cash flow challenges. It is worst when growing areas are not geographically widely spread, as in small countries like Israel and New Zealand; or if environmental growing conditions are fairly similar, as in California or Peru. In South Africa, with avocados produced under fairly variable climates and soils, the *national* crop shows less of the alternation typical of the above countries. However, on a regional basis, and especially on a particular farm, alternate bearing is certainly an issue.

The senior author was recently (July, 2009) invited to present two talks on alternate bearing to the 4th Australian and New Zealand Avocado Growers' Association Conference in Cairns, Australia. Alternate bearing (AB) was the major theme of the horticultural sessions, in a Conference dominated by marketing, handling, consuming, and avocado disease issues. New Zealand in particular is plagued by AB, as well as by irregular bearing (IB) in which the regular "on"/"off" crop alternation is regularly upset by cold spells during the critical flowering and fruit set period. The causes of AB and IB are still hotly debated in Australasia. Vested interests muddy the waters by not seeing the whole picture, and by shifting the focus away from the scientifically established facts.

More recently, a presentation was made to the KZN Avocado Study Group, organized by Subtrop Technical Advisor (KZN) Andrew Sheard. The authors developed "on" and "off" crop year phenological growth model charts for this meeting, and believe that they are helpful in understanding and managing avocado AB. We herewith offer them as a first approximation for humid, subtropical growing areas in South Africa.

We firstly emphasize that the causes of AB are complex and many. There are two main scientific theories. The "starch depletion" theory is based on the well-known correlation between starch storage reserves and yield potential in tree crops. Young avocado orchard yield typically rises in a fairly predictable way until a major crop is set, due to very favourable environmental conditions during flowering and fruit set. Until this time, the vegetative : reproductive balance is tilted heavily in favour of vegetative growth, as the basic tree structural framework develops. Therefore there has been a surplus of well-lit photosynthesizing leaves to meet the relatively small energy (carbohydrate) demands of light fruiting. Surplus carbohydrates are stored as starch reserves – the tree's buffer against extreme environmental and pest events.

The first heavy crop heavily depletes the starch reserves (from the pre-flowering winter peak), and reduces the recovery in starch reserves during summer and autumn. The following season's flowering is therefore less intense – mainly due to adverse effects on

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shoot and root flushes during an "on" season. The result is the "off" crop. This pattern then becomes entrenched, with "boom and bust" cycling.

However, this explanation is only part of the story. We now know that the heavy "on" crop results in high concentrations of anti-flowering gibberellin hormones, mainly in growing seeds. Some gibberellins moves to nearby shoot buds, and reduces flower bud initiation (in late summer and autumn) for the next ("off") crop. This is easily observed on heavy fruiting as compared with light fruiting branches. Undoubtedly, we do not yet know the ultimate causes of AB, but seed gibberellins undoubtedly play a role.

The grower is more concerned with *management* of AB – how can the boom/bust cropping cycle be ameliorated? In short, fairly drastic intervention is required – especially in more stressful environments where AB is more problematic. Growers have to buy into a full package of remedial measures, and by-and-large these are consistent with more intensive "best practice" management. Removal of excess (small) fruit early in the "on" season is surely the most obvious, but understandably the least popular option. Pruning restores vegetative vigour in "on" years where the balance has moved excessively towards fruiting. Girdling has a role to play (if properly used), as does the growth retardant uniconazole (Sunny®). Obviously, other management practices must be optimized, and Phytophthora root rot *properly* controlled.

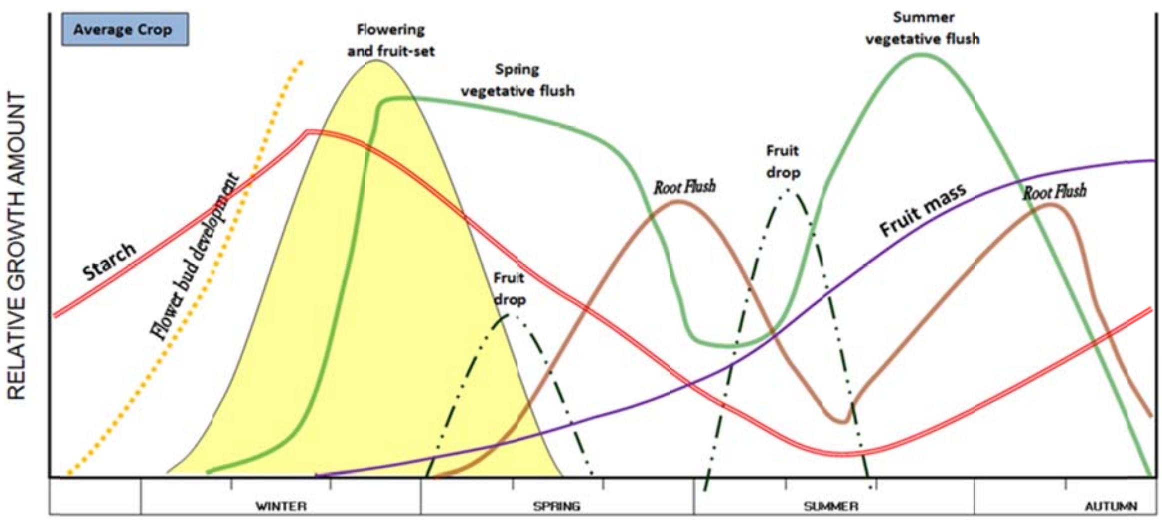

Figure 1. The total growth cycle of cv Fuerte showing the relationship between vegetative and reproductive growth and reserve starch in the trunks of trees (Whiley & Wolstenholme, 1990) Typical of a humid, subtropical climate; low ABI.

This brings us to the standard tool for guiding avocado orchard management – the Whiley *et al.* (1988) phenological growth model (Fig.1), well-known today throughout the avocado growing world – with adaptation to local conditions. But it is important to remember that this model was drawn up for very specific conditions, viz. avocado orchards in a mild (mesic) humid subtropical area, where AB is not a big problem (Whiley, A.W., pers. comm., 2009). It does not therefore look at the two-year ("on"/"off" crops) cycle typical of

AB orchards. The New Zealanders were the first to draw up a two-year chart, in the form of a circle with two hemispheres representing the on-off cycle, and pictorial representation of phenological events (flowering intensity, fruit drops, crop size, shoot and root growth flushes) (Hardy *et al.,* 2008). This is necessary to accommodate the fact that the Hass fruit here takes more than one year to mature, and can be hung on the tree for up to 18 months from flowering (incidentally, thereby greatly aggravating AB).

For average South African conditions, we present an avocado “on” crop growth cycle (Fig. 2), and the consequent “off” crop growth cycle (Fig. 3). This theme was developed in a “workshop on the avocado growth cycle” at the Cairns conference, and was emphasized in the senior author’s talk on AB (without actually drawing the explanatory figures) (Wolstenholme, 2009).

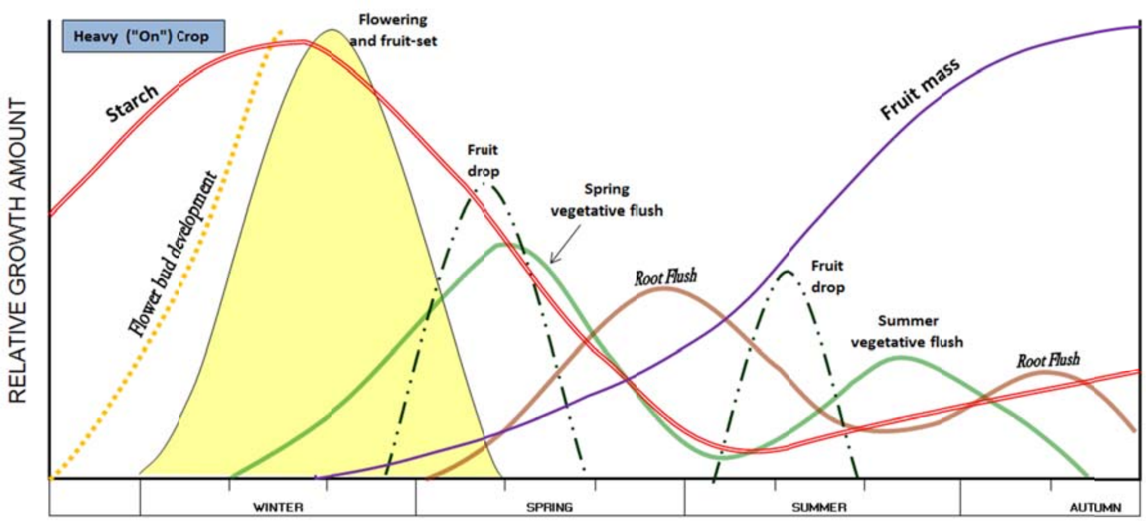

Figure 2. Phenological growth cycle in an "on" crop season, with vegetative-reproductive balance heavily biased towards flowering and fruiting (Wolstenholme, 2009, adapted from Whiley *et al*., 1988). Typical of more stressful environments, following an "off" season; High ABI.

Figure 2 (heavy crop, i.e. “on” year) graphically represents the situation where reproductive events dominate. Thus flowering is very intense: starch reserves start off very high, and there are plenty of fruiting sites (peripheral shoots) from the previous (light crop) season. Fruit drop will be prominent due to the sheer volume of flowers and initially set fruits. The harvested crop will still be very high because fruiting starts under very fruiting-friendly conditions, and preferentially appropriates most of the tree’s resources. All of this, of course, has a trade-off – vegetative growth loses out big-time. Thus the spring growth flush is reduced; the summer growth flush even more. These flushes provide the fruiting sites for next season’s (“off”) crop – simply put, not enough are formed. Just as important, the two root flushes (late spring/early summer, and especially the autumn flush) are reduced. So the tree goes into autumn and winter with a huge crop, but rundown starch reserves, fewer fruiting sites, less flower bud initiation because of all the surplus gibberellins sloshing about in late summer; and leaves which have been over-worked photosynthetically, are “tired” and more prone to photo-inhibition, and have been inadequately renewed by flushing. Talk about a recipe for disaster!

Fig.3 depicts the consequences of the “on” crop on the next season’s “off” crop phenological events. Here reproductive events play second fiddle. There is less intense flowering, with equivalent fruit drops, and a light crop. This results from low starch reserves, stressed leaves and roots during fruit set, and other physiological factors. Vegetative flushing of both shoots and roots however recovers dramatically – setting the scene for next season’s heavy crop, along with starch reserve buildup due to relatively low fruiting demand.

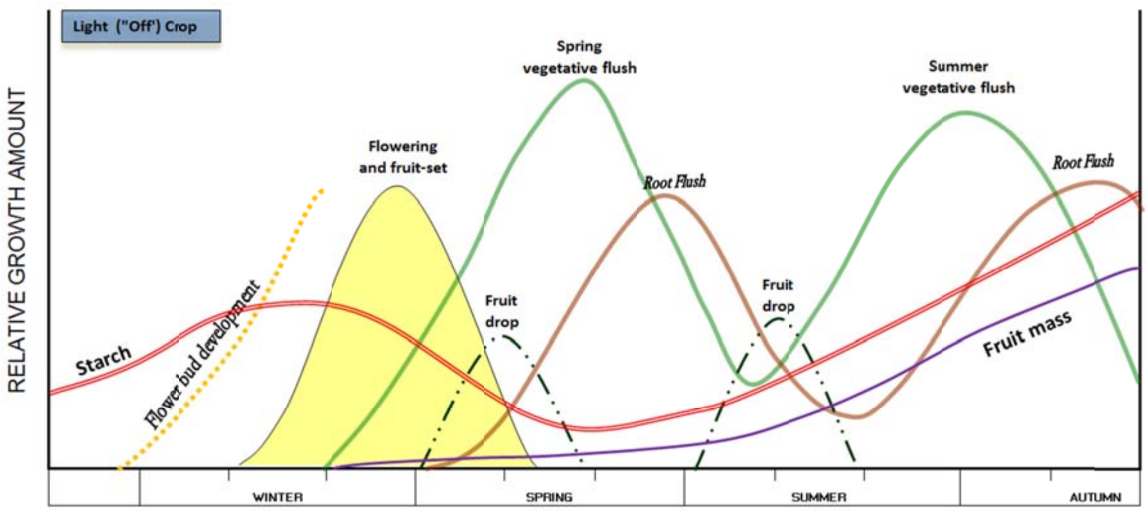

Figure 3. Phenological growth cycle in an "off" crop season, with vegetative-reproductive balance heavily biased towards flowering and fruiting (Wolstenholme, 2009, adapted from Whiley *et al*., 1988). Typical of more stressful environments, following an "on" season; High ABI.

The challenge for the orchard manager is to move the growth models in Figures 2 and 3 towards the “ideal” shown in Fig. 1, where the crop is average, and vegetative and reproductive events are nicely balanced. Starch reserves peak at about the same level in successive seasons. Figures 2 and 3 suggest what needs to be done. This is the topic for another occasion.

Acknowledgement

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