

ALTERNATE BEARING IN CITRUS

Alternate bearing is a problem that can cause tremendous financial losses in extreme cases. Below follows a short summary of what we know about alternate bearing in citrus and practical ways to reduce this problem.

1 Introduction

Alternate bearing (also called biennial or uneven bearing) is the tendency of a fruit tree to produce a heavy crop in one year (on-year) followed by a very light crop or no crop (off-year) as shown in Figures 1 and 2. However, in some cases an off-year can be followed by another off-year. Alternation is a widespread phenomenon, occurring in both deciduous and evergreen trees. Alternate bearing occurs in all climatic regions, temperate, subtropical and tropical, regardless of the optimal growing conditions for a particular species. Young trees with high vegetative vigour normally exhibit less alternate bearing than fully developed trees. Alternate bearing is a major problem in citrus production worldwide, especially in mandarin varieties. Many marketing problems result from alternate bearing. On-crop trees produce a large amount of small fruit and off-crop trees produce small amounts of large, rough and unattractive fruit. These problems cause a loss in stable income and market share and makes management practices such as irrigation, fertilization and the application of plant growth regulators very difficult.

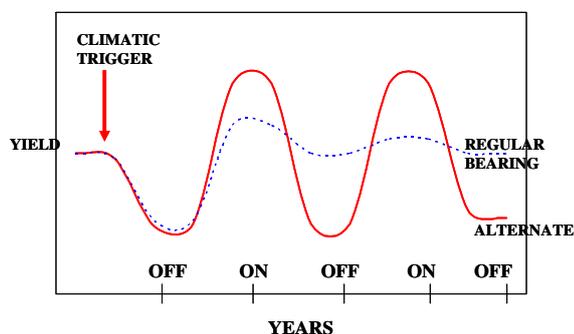


Fig 1. Schematic representation of the cyclic cropping of a regular and an alternating

cultivar in response to the same climatic trigger.



Fig 2. Two Pixie mandarin trees in the same block, one bearing an off-crop (left) and the other bearing an on-crop (right).

2 Where does it occur?

Alternate bearing may occur over an entire region, or a block of trees, or an individual tree within a block, or even a part of the tree or one branch, as shown in Figure 3. Alternate bearing is typically initiated by climatic conditions which can synchronize the fruiting habit of an orchard or an entire climatic region. Unfavourable climatic conditions that result in a low yield and initiate alternate bearing include a lack of chilling, flower destruction due to spring frost or excess rain, excessive fruit drop due to low air humidity, low temperatures, wind, high temperatures or drought stress during fruit set, and reduced vegetative growth due to summer drought. On the other hand, adequate chilling during flower induction and favourable conditions during flowering and fruit set, as well as stimulation of summer vegetative growth the previous season by pruning, can result in a heavy on-crop that initiates alternate bearing. The first trigger for crop alternation is therefore environmental, but the nature of the mechanism that continues (perpetuates) the cyclic bearing pattern is still unresolved.



Fig 3. Alternate bearing in half of a tree initiated originally by wind on the right side of the tree, causing abscission of flowers and fruitlets.

3 Cultivar differences

There are cultivar differences in the severity of alternate bearing. Alternation is much stronger with easy-peeling cultivars such as Satsuma (*Citrus unshiu*), Clementine (*C. reticulata*) and hybrids within *C. reticulata* or between the latter and sweet orange (*C. sinensis*) or grapefruit (*C. paradisi*). Early maturing cultivars like Satsuma and medium to late maturing cultivars like Clementine show severe crop alternation. Valencia orange shows moderate alternation and navel cultivars show less alternation. Temple and Minneola are relatively constant bearers, but there are exceptions. Some cultivars are prone to an absolute alternate bearing habit, which involves a total lack of flowering in the off-crop years following a heavy fruit load, rather than excessive flower abscission or poor fruit set. In such a case, the very heavy on-crop can cause the dieback and eventually the death of the tree.

4 Severity of alternate bearing

The severity of alternate bearing appears to be related to extremes in crop load and to late harvest in the on-crop year. In some cases, heavy crops are still on the tree during floral induction and sometimes during anthesis and initial fruit set and in these cases earlier harvest is not an option.

5 Effect of fruit on return bloom

Fruit have a definite effect on the number of flowers and the total number of spring shoots that develop in the return bloom. The lack of flowers in the off-crop year is characteristic of years following a heavy fruit load as shown

by Figure 4. The presence of a large number of fruit appears to have an inhibitory effect on floral shoot production as well as vegetative growth and, thus, reduces flower number and yield, rather than influencing fruit set. The number of flowers and yield is inversely proportional to crop load in terms of the number of fruit produced the preceding year. The length of the time the crop remains on the tree after maturity increases the degree of alternate bearing. Therefore, early harvest is very important to prevent alternate bearing.



Fig 4. The effect of fruit on the return bloom. Heavy on-crop trees (top) show no flowers and vegetative shoots in spring while the light off-crop trees (bottom) have a lot of flowers and vegetative shoots.

6 Effect of fruit on vegetative growth

Fruit have an inhibitory effect on vegetative shoot growth which leads to a reduction in potential bearing positions in the following spring. Biennial or alternate bearing can therefore be induced through a lack of flowering positions after an on-crop year. Citrus flowering should not be viewed independently from the previous crop and vegetative growth flushes that occur throughout the season. A heavy crop load

(on-crop) results in less and shorter summer shoots. Therefore, on-crop trees have very little or no summer vegetative flush, and this may reduce the next season's bloom. Also, in a sparse flowering year, most of the spring flush shoots will be vegetative and the few floral shoots produce a light crop, which in turn results in the production of many floral shoots and a few vegetative shoots in the next spring, which will subsequently result in a heavy fruit load. The number and length of vegetative shoots that grow throughout the season is very important to the return bloom. The balance between vegetative and reproductive growth in a tree is important for a constant yield year after year.

7 Effect of fruit on reserves

Starch is the most common reserve carbohydrate in plants. Starch and soluble carbohydrates constitute a reserve pool that can be remobilized for vegetative and reproductive growth. Reserve carbohydrates are mainly utilized to support reproductive or floral shoot development, whereas photosynthesis by mature leaves supports vegetative growth. During an on-crop year, reserve carbohydrates are utilized in flowering, fruit growth and fruit development. During subsequent on-tree storage of mature fruit, roots receive less maintenance carbohydrates and also utilize their stored reserves.

In general, the on-crop depletes starch in most plant organs, but it is not clear if starch exerts a direct effect on flowering or an indirect effect on flowering via the roots. Fruit load is negatively correlated with leaf, root, trunk and branch starch concentrations in winter and with floral intensity in the subsequent spring. After harvest, there is a rapid increase in leaf and root carbohydrate concentrations, especially starch. The correlative relationship of starch with flowering has led researchers to believe that low carbohydrate availability plays a direct regulatory role in limiting citrus flower formation and therefore alternate bearing. In contrast, in some studies, no consistent relationship between leaf and stem carbohydrate concentrations and flower formation could be demonstrated, indicating that carbohydrate availability is not always the factor limiting flowering. Other studies

also suggest an indirect role of starch via the roots, where an on-crop results in the depletion of starch in the roots and/or reduced root development, which in turn may exert an inhibitory effect on new shoot production and/or flowering. In some cases depletion of starch can be so great that trees collapse and die (Figure 5). The lack of flowering and new shoot production after an on-crop year, and eventually the decline and death of the tree, have been associated with a complete loss of carbohydrates from the entire tree and with the degeneration of feeder roots.

Crop load has a similar effect on nitrogen levels in the leaves. Leaves of on-crop trees have low leaf nitrogen concentrations compared to off-crop trees.



Fig 5. Complete tree collapse in Kinnow mandarin, the result of starch depletion from a very heavy crop load of small fruit.

8 What can we do about alternate bearing?

Alternate bearing can be controlled or softened by reducing the heavy on-crop or by increasing the light crop in the off-year in order to ensure a moderate crop year after year. Generally, the better option would be to reduce the heavy on-crop rather than trying to increase the off-crop.

Assuming you just had an off-year and you are anticipating an on-year. In an off-year, a more vigorous summer flush will develop. Management practices (irrigation, fertilization) should not stimulate too much vegetative growth and vigorous summer vegetative growth can be removed by light summer pruning.

- ◆ Prune heavier in the winter (selective or mechanical) after an off-year when an on-year is expected and when the orchard has a history of alternate bearing.
- ◆ Selective or mechanical pruning during bloom in the spring can also be used as a thinning method to reduce flower number.
- ◆ Depending on the fruit set achieved, a heavy on-crop can be reduced by thinning. Thinning can be done by hand, or with the synthetic auxins, Corasil P® (Dichlorprop P) or Maxim® (3,5,6-TPA). Refer to product labels and latest MRLs for thinning options and usage restrictions.

Assuming you just had an on-year and you are anticipating an off-year. Harvest your on-crop as soon as possible after maturity. Early harvest in an on-year plays a very important role in the intensity of the return bloom. Rows in large blocks harvested last will have a lower flower intensity in the return bloom than the rows where harvesting started. Early harvest, however, creates problems in terms of meeting colour standards in Navel orange and internal fruit quality standards in Valencia orange.

- ◆ Girdling before the onset of winter (flower inductive conditions) in late May/early June for early cultivars can improve the floral intensity in spring, but is not effective if fruit are still present on the tree.
- ◆ The light crop in an off-year can be increased by applying pre-bloom urea to improve flower quality.

Care should be taken in a few specific cases to ensure a yearly moderate crop load. Girdling trees with root disease in late May/early June if an off-year is expected can lead to very low levels of carbohydrates in the tree and return bloom will be adversely affected.

- ◆ Very low carbohydrate levels in the roots of some mandarin types due to girdling after an on-year can predispose trees to root diseases.
- ◆ The severity of pruning is also important. When trees are pruned heavily in the

winter before a typical off-year, after a heavy crop load it will exacerbate alternate bearing.

- ◆ Late hanging of fruit to meet colour or internal fruit quality standards also increases the severity of alternate bearing.

9 Conclusion

It is generally accepted that the number of fruit on a tree is the main factor influencing the floral intensity of the return bloom. The heavy on-crop reduces the number and length of summer and fall vegetative shoots and reduces carbohydrate reserves in all tree parts. For cultivars in which these flushes contribute significantly to spring bloom, the on-crop would reduce the number of sites on which to bear flowers the following spring. Alternate bearing seems to be due to the inability of branches to support flowering and vegetative shoot growth in the same crop-year. It is imperative that this balance between reproductive and vegetative growth be maintained or created to ensure a moderate crop load year after year.

10 Literature

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