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# Olive Tree Phenology: The relationship of fruit load to vegetative growth and return bloom

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The first step in researching and developing strategies for mitigating alternate bearing (AB) in 'Manzanillo' table olive is to model the tree phenology with respect to the alternating 'ON' (high yield) and 'OFF' (low yield) cycles. In olive, the vegetative growth in one year produces the nodes bearing potential floral buds in the second year. Fruit load suppresses vegetative growth and return bloom; however, the mechanism underlying this relationship is unknown.

Hypothesized mechanisms (or combinations thereof) include:
1) Fruit inhibit vegetative growth, resulting in fewer nodes with the potential to flower and bear fruit.
2) Fruit inhibit floral development and/or spring bud break, reducing the number of inflorescences at return bloom.
3) Fruit reduce the number of perfect flowers in return bloom, resulting in fewer flowers with the ability to bear fruit.

## Fruit load and inhibition of vegetative growth

*Relationship of fruit load to vegetative growth*. Olives are borne on one-year-old shoots; consequently shoot growth will be depressed during the year of a heavy crop, resulting in lack of fruitful shoots the following year (Sibbett, 2000). Working in both commercial orchards and at the Lindcove Research and Extension Center, our research team has similarly modeled this relationship in 'Manzanillo' olives in Tulare County. We assessed the influence of fruit on vegetative growth on 'ON' trees in comparison to 'OFF' trees, where 'ON' refers to trees with a heavy crop load, and 'OFF' refers to trees with a low or negligible crop load. Additionally, within 'ON' trees, we assessed vegetative growth on shoots bearing fruit and shoots not bearing fruit. The results of our study demonstrate the inhibitory effect of fruit on vegetative growth at both a tree and shoot level (Table 1). For example, between July 2012 and September 2012, an average of 3.3 nodes per shoot were produced on 'OFF' trees, whereas, non-bearing and bearing shoots on 'ON' trees produced an average of 0.7 and 0.6 nodes per shoot, respectively (Table 1).

**Table 1.** Vegetative growth represented by the cumulative number of nodes per shoot produced between July 2012 and the stated month.

| Tree Status 2012 | Shoot Status | # Nodes July '12 | # Nodes July-Aug '12 | # Nodes July-Sept '12 | # Nodes July-Oct '12 | # Nodes July-Feb '13 | # Nodes July-April '13 |
|---|---|---|---|---|---|---|---|
| OFF Control | No Fruit | 2.2 a | 2.9 a | 3.3 a | 3.3 a | 3.6 a | 5.0 a |
| ON Control | No Fruit | 0.6 b | 0.7 b | 0.7 b | 0.7b | 1.0 b | 2.7 b |
| ON Control | Fruit | 0.2 b | 0.5 b | 0.6 b | 0.6 b | 0.8 b | 3.3 ab |
| **P value** | | 0.0019 | 0.0047 | 0.0058 | 0.0059 | 0.0053 | 0.0397 |

<u>*Seasonality of vegetative growth*</u>. As a precursor to developing chemical treatments (e.g. Plant growth regulator) to mitigate AB, we investigated the fluctuation of growth rate by season (Table 1). The results of our 2012 data collection indicate that vegetative shoot growth proceeds through September, but effectively ceases sometime between September and October. Minimal vegetative growth occurs during the winter months (i.e., October through February), but the vegetative growth rate accelerates in the late winter/early spring (February-April).

<u>*When does vegetative growth on 'ON' branches effectively 'catch up' to growth on 'OFF' branches?*</u> Our data suggest that vegetative growth rapidly accelerates on 'ON' shoots between February and April; by April no significant difference was observed in the number of nodes produced since the preceding July for bearing shoots on 'ON' trees and 'OFF' trees. During the late winter/early spring, the fruit are no longer present to suppress vegetative growth, and formerly 'ON' shoots will effectively 'catch up' to the 'OFF' shoots. This late winter/early spring growth; however, will not produce inflorescences in the current year because they were formed after floral bud induction and development.

**Fruit may inhibit floral bud break**

Fruit inhibit return bloom in 'Manzanillo' olive (Table 2); however, it is yet unknown whether fruit only inhibit vegetative shoot growth, or also inhibit the formation of floral buds, or only inhibit the spring break of floral buds. Our research has documented the extent of fruit’s suppression of return bloom, with inflorescence counts highest on 'OFF' trees, followed by non-bearing and bearing shoots on 'ON' trees. The combined whole-tree and localized shoot effect on inflorescence counts was observed on bearing shoots of 'ON' trees, as evidenced by statistically fewer inflorescences produced per shoot than non-bearing shoots on 'ON' trees (Table 2).

**Table 2.** Influence of tree and shoot status on inflorescence production.

| Tree Status 2012 | Shoot Status | Total Inflorescences per Shoot |
|---|---|---|
| 'OFF' Control | No Fruit | 9.3 a |
| 'ON' Control | No Fruit | 2.8 b |
| 'ON' Control | Fruit | 0.6 c |
| **P value** | | 0.0001 |

Our current data suggests that, in addition to the loss of potential inflorescences due to the inhibition of summer vegetative shoot growth, at least a portion of fruit-mediated reduction of return bloom is related to reduced spring bud break. Floral buds of 'Manzanillo' olive are formed in late summer or early fall, but branch injections with the cytokinin plant growth regulators 6-benzyladenine or a proprietary cytokinin in February 2012 resulted in over 60% increase in number of inflorescences on non-bearing shoots on 'ON' trees at bloom in 2012, consistent with overcoming bud dormancy of viable floral buds. Our data, therefore, demonstrate that a portion of reduced return bloom is related to inhibition of floral bud break.

**…a portion of reduced return bloom is related to inhibition of floral bud break …**

**… shoots bearing fruit in year one will have fewer perfect flowers in year two.**

**Fruit reduce the percent of perfect flowers at return bloom**

Olives are andromonoeceous, meaning they produce both perfect flowers, containing male reproductive structure (stamens) and female (pistil) structures, and staminate flowers (containing only male parts). Staminate flowers are unable to bear fruit. During floral bud development, all buds contain pistils and stamens; however, pistil abortion approximately 8-10 weeks prior to bloom results in a reduction in the proportion of perfect flowers formed. The results of our research provide evidence that the bearing status of a shoot affects the percent of perfect flowers formed (Table 3). The results suggest that failure of the pistil to develop and form a perfect flower is strongly associated with the presence of fruit set on a shoot and not due to crop load since the percentage of perfect flowers on nonbearing shoots of 'ON' trees is equal to that of nonbearing shoots on 'OFF' trees, but dramatically reduced for bearing shoots on 'ON' trees. Consequently, shoots bearing fruit in year one will have fewer perfect flowers in year two.

**Table 3.** The bearing status of trees and/or shoots influences the characteristics of return bloom.

| Treatment | Shoot Status | Total Inflorescences per Shoot | Total Flowers per Shoot | Flowers/ Inflorescence | Total Pistilate Flowers per Shoot | % Perfect Flowers |
|---|---|---|---|---|---|---|
| 'OFF' Control | No Fruit | 9.2 a | 24.6 a | 3.3 a | 21.4 a | 87 |
| 'ON' Control | No Fruit | 0.2 b | 1.6 b | 1.6 a | 1.4 b | 88 |
| 'ON' Control | Fruit | 0.4 b | 0.0 b | 0.0 a | 0.0 b | 0 |
| *P*-Value | | ≤0.0009 | ≤0.0001 | ≤0.1745 | ≤0.0001 | |

**Summary**

As a result of collaborative work between UC Cooperative Extension and UC Riverside, we have enhanced the understanding of the phenology of 'Manzanillo' olive with respect to alternate bearing and the cycling of 'ON' and 'OFF' crops. This phenological modeling illustrates the influence of fruit on vegetative growth and the seasonality of vegetative growth. The work additionally addresses the influence of fruit on both return bloom and the number of perfect flowers produced. Last, our work on mitigation of AB in olive provided evidence that fruit reduce floral intensity by inhibiting spring bud break and that floral buds had developed.

Further studies are underway to elucidate the timing of flower bud development. We are currently investigating whether fruit inhibit floral development on bearing shoots of 'ON' trees by examining the expression of key genes that regulate floral development. Enhanced understanding of the phenology of 'Manzanillo' olive will allow for precision timing of practices designed to mitigate AB and minimize the annual fluctuations in crop load and industry inventory.

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