Alternate Bearing in Pistachios

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What is alternate bearing:

Alternate bearing occurs in many crops. Alternate bearing is defined as large crops followed by small crops. It can be defined numerically by an alternate bearing Index (I) of intensity with a scale ranging from 0 to 1. Total alternate bearing, a large crop alternating with no crop every other season is total alternate bearing, or I = 1. An equal crop every year is no alternate bearing, or I = 0. The alternate bearing intensity Index, I, can be calculated by the following formula:

$$I = \frac{(\text{lbs. marketable crop year 2} - \text{lbs. marketable crop year 1})}{(\text{lbs. marketable crop year 2} + \text{lbs. marketable crop year 1})} + \frac{(\text{year 3} - \text{year 2})}{(\text{year 3} + \text{year 2})} + \ldots \text{total years}$$

$$\text{(Number of Years Measured} - 1)$$

Using this formula over the entire California industry the alternate bearing intensity from year 1976 through 2002 was I = 0.31.

However, individual orchards can have much higher alternate bearing indices. For example, an orchard in Kern County monitored from 1985 through 1991 had an alternate bearing index of I = 0.88. In per tree terms this means a tree could alternate between producing as much as 50 pounds and less than quarter pound, per tree, or between 5,600 and 25 pounds per acre of marketable yield.

When does alternate bearing happen?

Alternate bearing commences when the orchard reaches full bearing and is initiated by the first large crop in which buds for the following season drop. Once alternate bearing starts it continues unless a heavy crop year is decreased for some other reason; frost, loss of crop before nut fill due to poor management, diseases or pests. In young, well maintained orchards planted in established production areas where pollen from existing orchards is plentiful alternate bearing con commence as early as the 8th year in the ground.

What causes alternate bearing?

The basic physiological cause of alternate bearing has not been determined. Generally, research indicates a competition for the carbohydrate resources of the tree, with a plant hormone signal directing the tree to complete the process, is what results in alternate bearing. The actual mechanism of alternate bearing varies in different crops. In citrus, particularly mandarins, the trees produce a sharply lower percentage of the flowers that produce fruit. In olives the tree fails to produce as many flower buds total. In pistachios the buds for the flowers that produce nuts are produced, but drop off the during the previous season's high crop production. So, in all crops the physiological cause and the net result are the same, but the specific observable mechanism varies.

In pistachios alternate bearing occurs within a single branch. The leaves on a single branch are what supply the carbohydrates for the developing buds and nuts on that branch. As the nuts on the one year old wood fill, buds on the current year's wood drop. The buds drop in sequence, those from the base of the branch dropping first. This drop generally starts in late June and is completed by the end of July. Branches within a tree, trees within an orchard, sections within an orchard, and entire orchards, can be out of cycle. Historically, entire industries are synchronized in gross production.

It has been suggested alternate bearing is an evolutionary adaptation to ensure survival in the harsh climates where pistachios first grew. If a tree had the ability to ensure a less demanding crop following a heavy crop it would give the tree an opportunity to rebuild carbohydrate storage reserves during the off year, ensuring survival in regions of limited resources. Additionally, the pest populations that built up during the year of heavy crop would decline during years of low crop. Again, aiding the tree's survival the following year. A tree with these qualities would have survived the centuries prior to domestication by man. If the tree also had a nut attractive to man for

production it would have been selected for domestication. Once domesticated, regular irrigation, fertilization and pest control would greatly hasten the production of ever larger crops until alternate bearing commenced with a heavy crop followed by a low crop. It has been suggested simply adapting to this pattern with would be the best way to handle alternate bearing. Particularly as alternate bearing has not thus far been demonstrated to harm the tree in any permanent way, and because crop flow to the market can be somewhat controlled by storage and carry over from the previous season. Further, it could decrease overall production costs, particularly pest management. However, an adaptation of this sort is difficult to incorporate into present farming operations. Therefore, it has not been tried experimentally.

What parts of the tree contribute to alternate bearing?

Alternate bearing is a function of the scion cultivar, 'Kerman' alone. A 13 year rootstock trial with the three major commercial rootstocks; Atlantica, Integerrima or Pioneer Gold I, (PGI) and the hybrid of the two, Atlantica X Integerrima, UCB-1, budded with buds from the same 'Kerman' scion all had alternate bearing indexes of 0. 61- 0. 67. This was true even though the trees on UCB-1 rootstocks produced significantly more marketable yield per tree than trees on either of the other two rootstocks. Therefore rootstock does not affect alternate bearing in spite of significantly affecting crop load. alternate bearing is a function of the 'Kerman' scion. This strongly suggests t efforts to control alternate bearing should focus on crop improvement through a focused breeding, acquisition and evaluation program.

What research has been done on alternate bearing?

Production research efforts have been directed at attempts to decrease alternate bearing by preventing bud drop during the heavy crop year on the theory that it is competition for carbohydrates that causes the bud drop. Thus far supplemental foliar fertilization, irrigation, and spraying the buds with 2,4 dichlorophenoxyacetic acid, (2,4–D) prior to bud drop have not resulted in any decrease in alternate bearing. The 2, 4 – D sprays retained the buds but caused the tree leaves to visibly senesce in late July and the retained buds produced poorly the following year. Current research with other plant growth regulators (PGRS) suggests that increasing the ability of the tree to retain buds can decrease alternate bearing. These PGRs function by making the buds more able to compete more effectively for the currently available carbohydrates. These PGRs are not registered.

The alternative approach is to decrease cropping on the heavy year. Theoretically this would reduce the carbohydrate drain on the tree and perhaps decrease the bud drop, ensuring a higher crop in the off year. The behavior of alternate bearing in pistachios suggests this would be the better approach. However, because pistachio bud drop is a within the branch phenomenon, for thinning to be effective it must be done within the rachis. Thus far no chemical has successfully thinned pistachios within the rachis.

What can be done to decrease alternate bearing? Ultimately the only thing that will control alternate bearing is breeding, using either traditional or newer molecular methods, or acquiring new cultivars to evaluate. However, these are a long term solutions that should be a part of a larger pistachio plant improvement program.

Until then the only available data based production practice that has successfully decreased alternate bearing is severe mechanical pruning, specifically topping. This work was done by Ferguson, Maranto and Beede from 1985 through 1991. The research rationale investigated was that if the tree could be pruned to produce more leaf surface area, and less nut rachii during the heavy crop year, there would be more leaf surface area to support nut fill, and build up tree reserves, and less nuts to deplete the current carbohydrate production. The process required two crop years to produce a tree that would then entered the off crop year two years later with more fruiting buds retained and more carbohydrate stores to support the retained buds. The effect of the initial off year pruning persisted through three alternate bearing cycles until the experiment was terminated. It is not known how long the effect would have persisted had the experiment been continued.

How to prune to prevent and decrease alternate bearing:

This can be done with either hand or mechanical pruning but the latter is more economical and effective. The pruning can either be a preventive, in the case of young trees not yet alternate bearing, or rehabilitative in older, alternate bearing, trees.

The most effective pruning practice for controlling alternate bearing is topping. In younger trees begin topping at 5-7 years of age; after the second or third crop. Top at least 2/3rd to 3/4th of the first growth flush of one year old wood every other year. Continue this to the maturity. If alternate bearing develops, top more severely, and remain on an every other year cycle. If alternate bearing is low decrease to an every third topping year cycle.

In mature trees that have commenced alternate bearing mechanical pruning must begin the year after a heavy crop and entering a low crop year. This is because the pruning will decrease yield, and losing 60% of a very light crop is less devastating over a two year cycle than losing 60% of a heavy crop. Also, the rachis can compensate within itself for rachis removal throughout the tree. Therefore it is possible severe topping prior to a high crop may not decrease crop sufficiently to mitigate alternate bearing. So, entering an off crop year the trees should be topped ½ to 2/3ds into the first growth flush of two year old wood. The following off year this wood will produce primarily vegetative growth that should be topped at the end of the season by at least ½ of its first flush growth. The following on year the topped wood will produce buds that will produce crop in the following off year. This mixed fruiting and vegetative wood may be topped lightly, depending upon proportion of fruiting wood. If it is high, tip lightly. From then on the alternate bearing cycle will be modified and the tree should require light annual light topping/tipping either every or every other year. Experimental data demonstrated a 1985 severe topping followed by topping in 1986 produced a modification in alternate bearing that persisted, without cumulative yield loss, through 1991. As the experiment was terminated in 1991 it is unknown how long the effect would have persisted. However, if alternate bearing again becomes severe the severe topping treatment should be repeated.

Recommendation for topping to control alternate bearing:

Young Trees: to prevent alternate bearing
Begin topping at 5 -7 years.
Top 2/3rd to 3/4th of first growth flush.
Repeat light tipping/topping every other or every third year.

Mature Trees: to decrease alternate bearing
Year 1:
Begin topping after a heavy crop and before a light crop.
Top ½ to 2/3rds into first flush two year old wood.

Year 2:
Retop by ½ into first flush of growth produced the following year.

Year 3:
Retop/tip lightly every year or every other year until alternate bearing resumes returns in the form of a very light crop; this should be in no less than six years.

Literature; available from California Pistachio Commission or first author

L. Ferguson, J. Maranto and R. Beede. 1995 Mechanical Topping mitigates alternate bearing of 'Kerman' pistachios (*pistacia vera* L.) HortScience (30) 6: 1369-1372.