



Management of Alternative Bearing in Citrus Varieties-Review

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Abstract

Alternate bearing phenomenon is the tendency of some citrus varieties to produce a heavy crop in ON year followed by little crop in next year OFF year, in both seasons the crop fruit with poor quality (improper size, thick rind, and unattractive color) which had low economic value, consequently decrease producers profit.

There are sensitive citrus varieties for alternate bearing like Mandarins and Tangerines, while grapefruit and pineapple orange have a moderate tendency; however, it is very weak in Valencia orange trees. There are various internal and external factors effects on alternate bearing cycles include low C/N ratio, unbalanced hormones, and starvation of roots, abiotic stress conditions and availability of nutrition in the soil. There are negative effects for alternate bearing in sensitive varieties, such as broken the limbs in ON year, delayed fruit maturity, reduce fruit quality. Management of alternate bearing to increase crop in OFF year by using different practice including thinning fruit, hard pruning after OFF year, foliar application by chemical substances like Gibberellin acid and urea.

Keywords: Alternate bearing; Citrus; Mandarin; C/N ratio; ON year; Fruit thinning

Abbreviations: AB; Alternate Bearing; ON Year; Heavy Crop Year; OFF Year; Little Crop Year; C/N Ratio; Carbohydrate/Nitrogen Ratio; GA3; Gibberellin Acid; ABA; Absciscic Acid; IAA; Indole-3-Acetic Acid; NAA; Naphthalene Acetic Acid.

Introduction

Alternate bearing phenomena (also called biennial) is the tendency of all trees (including deciduous and evergreen fruit trees, nuts trees and even forest trees) to produce a heavy crop one year (ON) followed by a minor crop or no crop the following (OFF) year, wherever it called "masting phenomena" in forest trees despite their vegetative cycles and annual reproductive. On-crop trees produce a great number of fruits with low quality (small size and unclear

color) which had a little commercial value, whereas in off-year trees produce a little fruit with poor fruit quality such as very big size, unattractive color, and a thick rind, after trees have a heavy crop, it often responds in the next season by carrying a little crop.

The severity of alternate bearing varies over time and also among citrus varieties [1], alternative bearing considered a normal phenomenon in some citrus varieties, it is a serious problem on mandarins and Tangerines varieties [2-4], however, alternative bearing is a moderate problem on pineapple orange and grapefruit, and it occurs sometimes in Valencia orange as a minor problem [5]. No doubt, management of alternate bearing phenomena represents a wide challenge for citrus producers to understanding and dealing with this problem.

There are different the agricultural practice used to management alternate bearing (AB) including pruning, thinning fruit, use exogenous substances and balanced nutrition. The effect of fruit thinning rate on regulating annual crop and fruit quality of various sensitive varieties like Balady mandarin and Kinnow mandarin, which considered as the most favorite fruit in the different market worldwide due to superior quality and its nutritive values [6].

Alternate bearing

Alternate bearing (AB) phenomenon is the processes in fruit trees by which cycles of heavy yield (ON crop) one year are followed by a light yield (OFF crop) the next. Heavy yield usually decrease flowering intensity the next year [7]. Once this pattern established it is hard to tree back to regular cropping annually, then alternate bearing occurs synchronously, also, this phenomenon can take place in individual blocks, in single trees within an orchard, in an entire side of the tree canopy, or one branch only. In general, the ON and OFF cycles are biennial, however, sometimes an ON year can be followed by two or more repeated OFF years and conversely after OFF year.

Flowering intensity decreased during OFF year which reduced flower number and sometimes fruitlet drop increase due to nutrient deficiency consequently decreased total yield, and there is strong vegetative growth, however, during ON year there is a limitation for shoot growth and total yield increased [8,9]. Some citrus varieties are subjected to alternate bearing, like Mandarins, Tangerines, grapefruit and pineapple orange, which in ON year trees has heavy crops with small fruit, however, in OFF year tree produce much smaller crops of larger fruit.

There is a relation between the time of differentiation of flower bud and alternate bearing phenomenon; the timing of flower bud differentiation in spring is the same time of new flush growth initiation, therefore, directly after initiated in ON year, the crop load affected on endogenous tree factors that finally impact the floral intensity which decreases blooming in the following season. Alternate bearing has significant economic consequences in citrus production, in OFF year tree produce a low crop, the fruit is very large, conversely, during the ON year, and much

small-size fruits with poor quality and low economic value are produced.

Hypotheses of alternate bearing: The mechanism that explains alternate bearing phenomena by which crop influences flowering and yield of the next year, is not completely understood, there are two hypotheses have been suggested.

The “nutritional” hypothesis: suggested that tree carbohydrate reserve determined bloom and yield, consumed of carbohydrate in the ON year effect on root ability to uptake nutrients which reduce return bloom the following year, so, there is a correlation between carbohydrate status and the alternate bearing [10,11], however, there are a number of studies have reported that there is no relation between carbohydrate reserve and return bloom or floral intensity [12].

The “hormonal” hypothesis: proposes that during ON year while fruit growth, it produces different substances such as Gibberellin acid (GA₃) which is known as inhibitor of flowering in citrus [13]. Also, there are different paper have shown correlations between abscisic acid (ABA) and indole-3-acetic acid (IAA) and alternate bearing status [14]. The roles of carbohydrates and hormones in AB remain uncertain and more research is required to clarify different factors affecting floral intensity following ON and OFF years.

Sensitive varieties: Alternative bearing considered a normal phenomenon in some citrus varieties, which trees produce extremely intense yield of small fruit in ON year and minor crops of bigger fruit in the OFF year. Mandarins and Tangerines considered the more susceptible varieties for alternate bearing which showed severe alternate bearing compare to other citrus varieties [2], followed by pineapple orange and grapefruit which has a moderate problem, however, alternate bearing represent a minor problem in Valencia orange [5].

Balady mandarin (*Citrus reticulata* Blanco) is known for its alternate bearing tendency, in ON year there are a lot of fruits but with poor fruit quality due to effect of heavy crops which delayed fruit maturity, poor rind color and small sizes that are unmarketable, also, during ON year heavy crops of mandarins could broken branches and destructive to the health of the tree (Figure 1), also, Kinnow mandarin has a strong tendency to alter bearing.



Figure 1: Image field for effect of heavy bearing on mandarin tree.

Murcott collapse: considered a clear example for alternate bearing phenomena, it occurs when Murcott mandarin trees loss of their leaves and fruit rapidly during the fall or winter of an ON year [15].

Reasons for alternate bearing: Alternate bearing in citrus are occurring due to various factors which begin alternate bearing cycles by eliminating the crop in one year particularly in suspicious varieties, therefore, different factors like losing nutritional balance in this varieties increase occurs of alternate bearing phenomena, also, this phenomenon could be related to the time of flower bud differentiation and crop load, therefore, these factors are divided into two groups as follow:

- a. Internal factors:** within the plant such as low carbohydrate reserved in plant tissue, unbalanced C/N ratio, malnutrition like Magnesium and Manganese deficiency, unbalanced hormones and starvation of roots.
- b. External factors:** include abiotic stresses (drought, salinity and heating stresses), diseases and soil nutrition status.

It seems that there is a relation between alternate bearing and time of flower bud initiation which occurs at the same time of new growth initiation and crop load; therefore, there is a limited or tinny flowering after heavy crop "ON season", but, in some cases occur heavy flowering but followed by serious fruitlet drop. Alternate bearing cycle continued in suspicious varieties like pineapple orange until change some effective factor like environmental

conditions or balanced nutrition to adjusted the bearing cycle, [7].

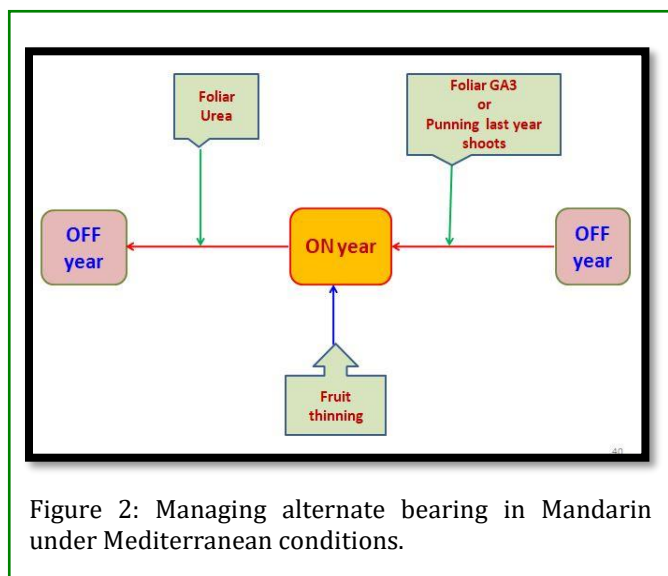
During ON season a large number of fruits on the tree consume the main part of carbohydrate in the tree and the roots suffer from carbohydrates deficiencies consequently, reduce their ability to absorbed nutrients. As a result of nutrients deficiency unbalance hormonal occurs, then affected on the flower bud formation in OFF year.

Negative effects of alternate bearing

- a. Alternate bearing in mandarin could be destroyed to the tree, the limbs and maybe branches broking as a result for the heavy crop in ON year.
- b. Heavy load in mandarin delayed fruit maturity, produce small size fruits and reduce fruit quality [3].
- c. Under alternate bearing tree subjected to dieback or complete death [16].
- d. Alternate bearing effectively negatively on fruit quality, it is more appearing in fresh market fruits, during ON year in grapefruit and orange produce fruit with small size, a misshapen and poor quality which reduce the marketable value.

Managing alternate bearing

The objective of alternate bearing management is reducing the severity of AB by increase yield in OFF year particularly in sensitive varieties, many papers discussed various suggestion for this problem, there are different horticultural practice used to manage alternate bearing including, thinning fruit, pruning, use girdling branches technique and other management practices (Figure 2) that reduce final crop and increase fruit quality in ON years to improve economic benefit.



There is a various practice used to management alternate bearing as follow:

1. Heavy pruning after harvesting in OFF year (Figure 3) including manual pruning, topping, and mechanical hedging [17].



2. Fruit thinning: reduce fruitlet number in ON years to improve fruit set and crop yield in OFF years, there are different methods used to fruit thinning such as hand thinning during ON year till the end of June to remove about 20-35% of fruit [18], and chemical thinning with NAA in mid of May during ON year.

3. Girdling branches during summer in ON year [19].
4. Balanced nutrition: reduced alternate bearing index significantly [20].
5. Foliar application of GA₃ during winter after OFF season to reduce flowering differentiation, improve fruit set and increase vegetative growth [21].
6. Foliar application of urea about from mid-December till mid-January in OFF years, to reduce flower bud induction for adjusting the alternate bearing cycle [20].

Generally, alternate bearing could manage through cultural practice which could help to manage these phenomena in citrus [22].

Fruit thinning

Fruit thinning one of agricultural practice to control alternate bearing, it is reduced fruit number and improve its quality during ON year, caused a significantly decreased in fruits number and yield/tree and relative yield during first season (on-year) [18], while, during OFF year, fruit thinning increased the tree crop compared to unthinned ones. Preferred thinning fruit when fruit diameter about 25-30 mm, as hand thinning by removing fruits from the outer circumference to remove about 35 % from total fruit.

Thinning techniques

- a. Manual thinning: start when diameter reaches to 25-30 mm till the end of June, by removing fruit and left another one from the outer circumference to remove 20- 35 % of the fruits on the tree [18].
- b. Chemical thinning: by use some chemical substances like NAA and ethephon during summer which considerable thinning during ON year [21].

Conclusion

Alternate bearing phenomenon is the tendency of some citrus varieties to produce a heavy crop in ON year followed by little crop in next year (OFF year), with poor fruit quality in both seasons reduce producers income. Mandarins and Tangerines considered the most sensitive varieties for alternate bearing, while grapefruit and pineapple orange have a moderate tendency, there are different factors effects on alternate bearing include unbalanced C/N ratio, unbalanced hormones, and starvation of roots, abiotic stress conditions and reduce nutrient in the soil. Alternate bearing had negative effects in sensitive varieties like breaking the limbs in ON year, delayed fruit maturity; reduce fruit quality as a result for the heavy load. There are different horticulture practice could use to regulate alternate bearing practice including thinning fruit, hard pruning after OFF year, foliar

application by chemical substances like Gibberellin acid and urea.

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