



Review Article

Short Gun Approaches for Alternate Bearing Control in Olive- A Review

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Abstract | Alternate bearing (AB), is mostly common in few tree crops which is defined as low or no fruit yield during one year and high yield during the succeeding year. It is mostly occurred due to some climatic conditions, varietal genetic variability and some endogenous hormonal balance. Alternate bearing results into poor flowering, low pollination, low fruit set and fruit drops. All these factors are the climatic factors dependent which can be controlled by proper irrigation scheduling, proper pruning and proper dose and source of fertilizer application at a proper growth stage. As a result, OFF season crop in once year and followed by ON year crop. Alternate bearing cannot be completely controlled but it can be minimized by adopting different approaches like mechanical pruning, pruning through use of growth inhibitors, use of bio stimulants, and proper use of mineral nutrients at proper nutrient demanding growth stage and use of different vitamins and amino acids. The current review was prepared by highlighting the use of these approaches for alternate bearing control in olive.

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Keywords | Climatic variation, Fruit yield, Olive fertilization, On- year crop, Off-year crop



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Introduction

Global cultivated area for olive is 12763184 Hectare and worldwide olive production is about 23640307tons (FAO, 2020). Olive growers facing the problem of alternate bearing, which affects both deciduous and evergreen plants. Comparatively it is mostly common in old olive trees (>10 years) compared

to younger one's olive fruit trees (3-5 years old) (Kour *et al.*, 2018; Haim *et al.*, 2021; Haberman *et al.*, 2021). The primary reason of alternating bearing is nutrient deficit during the early stages of bud development and blooming, which leads in flower bud induction. Tree pruning and applying nutrients at the appropriate stage are the prior approaches for alternate bearing control. Alternate bearing may also be restricted by

the irrigation schedule. Consideration should also be given to mineral nutrition. Nitrogen deficit impairs vegetative and fruit vigour, as well as flowering in spring following the flower bud differentiation phase (Dastkar *et al.*, 2020; Cabezas *et al.*, 2019).

The consumption for oil import can be minimized by cultivating olive crop in marginal land. Already cultivated olive in Pakistan is about 4039768 trees which is an indication of huge potential of this crop in Pakistan (Khaliq *et al.*, 2020; Jan *et al.*, 2021). There is sufficient potential for *Olea europaea* cultivation in Pakistan. Pothwar area is an arid region of Pakistan which is enriched with natural vegetation (Sumrah *et al.*, 2021). There are many industries which can work in Olive sector like oil processing, value addition, pharmaceuticals, cosmetics and feed industries (Sumrah *et al.*, 2021).

The development of cottage industry has the potential to attract rural women and youth in the olive business. The gradual increase in olive production is attracting the industrial sector investors to establish its commercial orchards and have their own olive oil brand in future. Izhar Group, SB Group, Sehgal's (P), Bagh e Zaitoon, Pak Olive, Unique Value and Allah wala Olive Farm and such other potential players are working on these lines. This will generate jobs to locals in the long-run. In addition to extraction of olive oil, olive leaf has great medicinal value and high potential for containing an antioxidant "Oleuropein" - a natural medicine helpful in treatment for cardio-vascular diseases. Impressed by the potential and with support from BARI, Izhar Group has been able to launch "Olive tea" in Lahore. Beside this different Olive value added products are being prepared different stakeholders like Olive pickles, Jam, Muraba, Squash, Gur and Biscuits giving a new direction for olive industry in future (Khaliq *et al.*, 2020; Sumrah *et al.*, 2021).

The current review was prepared by keeping in view with the objectives to highlight those factors which are responsible for alternate bearing in olive and how these can be minimized by adopting different approaches.

Factors responsible for alternate bearing

External factors: The principal causes of alternating bearing are flower-site constraint, endogenous plant growth hormones, and carbohydrate storage. A

significant number of staminate (male) flowers that don't develop fruit can occur 8-10 weeks before blooming. If adverse climatic condition causes crop loss during "On" year, the season may be turned into a "Off" year (Sofo *et al.*, 2018; Garcia *et al.*, 2021). Flowering may be hindered by temperature restrictions, which are a common occurrence in the climate. The principal causes of alternating bearing are flower-site constraint, endogenous plant growth hormones, and carbohydrate storage. Congestion the next year can be a result of a fruitless season caused by hot temperatures and dry winds, as well as severe rain or frost. Extreme temperatures can also hinder pollination and making fertilisation incompatible. The stigma's sensitivity becomes also minimized through wind and high temperature (Ben-Ari *et al.*, 2021; Montemurro *et al.*, 2019).

Internal factor

Endogenous plant growth hormones: Most alternate-bearing species are characterised by the absence of flower buds in the "ON" year. Abscissic acid (ABA) is a key growth hormone in alternate bearing control (Kafkas *et al.*, 2020). Among growth regulators, Indole Acetic Acid (IAA) and Gibberellic Acid (GA3) are the important ones for the control of alternate bearing (Bajpai and Bajpai, 2021; Goldschmidt and Sadka, 2021; Bajpai and Bajpai, 2021; Benjeddou *et al.*, 2019; Gad and Ibrahim, 2018). Hormonal balance will decrease during fall and winter and start to increase during Spring and summer. During the "On" year's levels of kinin-like cytokinin increased while ABA decreased during November and December (Ashraf *et al.*, 2018; Dastkar *et al.*, 2020; Fazeli-Nasab *et al.*, 2021).

High concentrations of phytohormones, particularly GA3-like compounds, favoured vegetative bud creation during the spring initiation period, while lesser quantities favoured floral bud formation. In July, November, January, and March, endogenous phytohormone levels were discovered to be crucial for floral bud induction and development. High levels of endogenous hormone stimulate vegetative bud creation during these months, while low levels encourage flower bud formation (Kafkas *et al.*, 2020; Abo-el-Ez *et al.*, 2018). Hormonal control, nutritional and blooming site limitation are the three key regulatory processes involved in alternate bearing induction. The nutritional variability of a tree is commonly cited as a crucial element in triggering

alternative bearing (Mert and Barut, 2018).

Nutritional factor

There are four stewardship for a better nutrient use efficiency i.e. Right source, right method, right time and right placement. In case nutrient uptake form, NP anionic form (NO_3^- and PO_4^{3-}) and K^+ are preferable form for olive. Nitrogen considered for foliage growth, P is important for energy transfer and to hasten the maturity while K application improve fruit quality and improve pulp content of olive. Alternate bearing may be exacerbated by nutritional deficiencies. For optimum bloom, fruit set, and yield, sufficient nitrogen dose should be provide.

Nitrogen is mostly applied to support new growth during the 'On' year (Haberman *et al.*, 2021; Pascual *et al.* 2019). From the beginning of the season up to August, potassium concentration in current season leaves decreased up to autumn. As the season passes, the leaf K concentration in most tree crops drops (Jan *et al.*, 2021). A quick drop of K during March have a significant impact on reproductive structures of the olive (Haberman *et al.*, 2019).

Crop load

Flowering load (year with a lot of flowers is followed by a year with few or no flowers) has a large influence on alternate bearing in olive. Heavy flowering during one year is followed by very few or no flowers to the succeeding year affects fruit production. The heavy fruiting during the growing season is probably the most well-known cause of alternation. Fruit load is a crucial factor for biannual bearing, frequently causing the balance of reproductive and vegetative processes (Lodolini *et al.*, 2010). Flowering load has a substantial impact on alternate bearing in olive. Trees with fewer blooms had longer ovule lifespan than trees with more blossoms (Dastkar *et al.*, 2020; Trentacoste *et al.*, 2019; Fernandez *et al.*, 2018).

Amino acids and phenolic

Endogenous levels of asparagines, glutamine, and tryptophan increased gradually but significantly from October to May of the 'Off' year. Asparagines, glutamine, and tryptophan all showed a similar trend throughout the "On" year. During winter and autumn seasons low amino acid produced due to limited N uptake from soil due to acute water stress, as well as their faster utilization in the plant system for biosynthesis of mono and polyphenols and soluble

proteins, resulting in a decrease in endogenous levels (Ali *et al.*, 2019; Tekaya *et al.*, 2021).

Plant leaves contain phenolic chemicals that have been linked to a number of physiological processes. The initial signal for alternate bearing is assumed to be received by the leaves of olive trees (Mert and Barut, 2018). Phenolic and flavanolic chemicals presence in the leaves prevents the production of flower buds during the physiological initiation period. Phenolics, both constitutively and as freshly induced molecules, operate as UV-protective agents in plant tissues and are commonly implicated in plant-pathogen interactions (Lama-Muoz *et al.*, 2020; Mert and Barut, 2013).

Mitigation of alternate bearing

There are several methods for reducing the harshness of biennial bearing. Application of various bio stimulants, vitamins, growth hormones, amino acids, thinning, girdling, pruning, fertiliser scheduling, and irrigation at vital periods are all things that must be controlled.

Pruning

Pruning is branches removal that are diseased, dead, or previous year fruit bearing branches. During December end and January, olive trees can be pruned. Lo Bianco *et al.* (2021) found that heavy pruning of olive cultivar Frantoio made it more likely to produce fruit. Pruning thorough use of chemicals i-e. Hexaconazole treatment is also a way to increase fruit set in a way that is both safe and effective. This substance's effect on plants can be likened to Chemical pruning, because it changes the distribution of carbohydrates between shoots and flowers growth (Mesejo *et al.*, 2020; Rodrigues *et al.*, 2018).

Pruning should be start from top to bottom and make tree in cup shaped or V shaped. Judicial removal of branches which are interlinked is the proper way of pruning Olive. Shoots with a larger diameter are removed first, followed by those with a lower diameter (Aiachi *et al.*, 2021). The suitable time for pruning of green olives is during November-December while February-March is suitable time for black olives. At a height of between 60 and 80 centimetres above the ground, newly planted one-year-old trees are clipped (Castillo-Ruiz *et al.*, 2021). It's imperative that during pruning of a large branch not damage the remaining branch's bark. Once the branch has been cut to the desired length, a second cut is done to remove the

branch from the lower portion of the tree (Rodrigues *et al.*, 2018; Garca *et al.*, 2020; Atmaca and Ulger, 2021).

Irrigation

Irrigation is an important factor consideration because absorption of nutrient and further its translocation to different parts is possible through water uptake. In case of olive, its important to give stress to plant otherwise plant focus on vegetative growth rather than flowering. To limit the extent of premature pistil abortion, three irrigations should be applied: Before flowering, during flowering, and after blooming. Irrigation should be used with the goals of avoiding excess fruit drop during fruit set and reducing pre-harvest fruit drop during maturity (Alcaras *et al.* 2021; Santos, 2018).

Fertilization

Significant amount of nutrient loss due to pruning, fruit removal and natural leaf drop. Extra nitrogen application before flowering and fruit set has been shown to be advantageous. It also boosts the olive tree's ability to absorb other nutrients. Fertilizers should be applied at the appropriate rate, such as NPK in January (before flowering), NK in June (after fruit set), and NK in August (after the pit hardening stage) (Habermman *et al.*, 2021; Zouari *et al.*, 2020; Rodrigues *et al.*, 2018). The use of organic sources are also helpful for olive orchards because organic sources application improve soil physical properties like soil texture, infiltration rate, water and nutrient holding capacity as well as improve chemical and biological properties (Mehmood *et al.*, 2020, 2021).

Foliar application of bio stimulants and amino acids

Glycine and glutamine amino acids: Proline, glycine, and betaine amino acids are all considered secondary metabolites. They are the building blocks of proteins, which are the fundamental component of living cells and play important roles in a variety of metabolic events. Furthermore, amino acids detoxify toxins and heavy metals in plant cells (Dabbaghi *et al.*, 2018), optimise nutrient uptake, translocation, and metabolism, vitamin biosynthesis, growth bio stimulation, creating higher tolerance to environmental stresses such as drought, salinity, and cold conditions, and synthesis and production of amino chelate fertilizers (Dikilitas *et al.*, 2020).

In higher plants, pollen germination and pollen

tube expansion serve as the foundation for double fertilisation, which is a vital stage in the plant's life cycle. To finally develop a sophisticated signalling network that governs pollen germination and pollen tube growth, the process must recognise and integrate a wide range of signalling chemicals, including Ca^{2+} , ROS, NO, H_2S , and plant hormones (Al-Isaw *et al.*, 2021; Mehmood *et al.*, 2022).

GA induced vegetative growth while blocking flower bud induction, whereas fruit removal, seed destruction, or application of anti-gibberellic chemicals caused the buds to differentiate into flowers. The high levels of GA released by seeds in plentiful fruiting years may be responsible for reduced flower development during the next year, and thus be the source of alternate bearing, which is common in olive by lack of lower bud induction. Other researchers have shown that amino acids, notably glutamine and asparagine, are quite beneficial in boosting floral induction in olive and other species (Bastam *et al.*, 2021).

Vitamins and amino acids

Researchers showed that vitamins and amino acids were extremely helpful in boosting growth, pigmentation, and nutrient content (Hussien and Gad El-Kareem, 2021; Hussein and Mohamed, 2017). The importance of amino acids in enhancing the biosynthesis of all types of proteins, DNA, RNA, different enzymes, antioxidants, vitamins, cell division, sugar building and movement, as well as their roles as important antioxidants responsible for inhibiting the formation of ROS (reactive oxygen species), which caused significant damage to the permeability of cell walls and the deposition of sugars, may explain their stimulating effect on fruit crop growth and fruiting. Notably, their critical roles in natural hormones formation including tryptophane and ethylene cannot be neglected in this regard (Ganie, 2021).

Paclobutrazol (PBZ) and naphthalene acetic acid (NAA)

In a wide variety of fruit tree species, the triazoles group (PBZ and uniconazole) has been shown to suppress vegetative growth (Desta and Amare, 2021; Mog *et al.*, 2019; Tesfahun, 2018). As a result, they are utilized to lessen the amount of pruning requirement (Tran *et al.*, 2018). The application of triazoles (PBZ) to irrigated large olive trees of the varieties 'Manzanillo' and 'Barnea' has no significant influence on their vegetative growth, it does have a considerable impact on their yield (Ajmi *et al.*, 2020).

For young (1 to 3 years old) olive trees of the varieties Kalamata, Manzanillo, Muhasan, and Leccino, growth inhibition has been seen in contrast to growth stimulation (Moreira *et al.*, 2016; Yungkham *et al.*, 2017). As a result, additional experiments are required to better understand the effect on the behaviour and productivity of the olive tree in relation to variations in the endogenous contents of phytohormones following the application of PGRs in order to better understand the effect on the behaviour and productivity of the olive tree (Ajmi *et al.*, 2020). Naphthalene acetic acid (NAA) is an organic compound that is a plant hormone in the auxin family. It plays an important role in fruit formation, abscission cell elongation and photoperiod. NAA is used for fruit thinning to reduce alternate bearing and improve fruit quality.

Conclusions and Recommendations

From the above-mentioned reviews, it was concluded that the main cause of alternate bearing is the inhibition of flower bud induction by the seed of growing fruits, which is caused by nutrient competition and hormonal imbalance. Pruning and productivity are the two main factors that can reduce the intensity of alternate bearings. Additionally, the irrigation schedule may limit alternate bearing. Mineral nutrition is also an important consideration. Nutrient deficiency, particularly of N during the flower bud differentiation period, affects the vegetative vigour, fruit size, and flowering of the following. Potassium deficiency at blooming stage will results into small size and fruit shedding and low oil quality and quantity. Increasing demand of olive products and extra virgin olive oil enforcing farmers to produce more and more but it will be possible when can control the alternate bearing issue of Olive by adopting different approaches like use of proper dose of fertilizers and foliar application of bio stimulants as well as vitamins and amino acids at blooming stage. Finally, it is recommended that alternate bearing can be minimized by applying right source at right time. First dose of N, all P and K should be applied during December and January, second dose of N should be applied at fruit development stage (pea size fruit) and third dose during November will be proven for a good yield. Secondly, it will be a great initiative if the fertilizer companies (Syngenta, Erysta, Saver, Agro and FFC) will add these amino acids into solution fertilizer. Secondly farmer adopt such a fertilizer schedule that's application result into maximum floral

bud initiation during the ON season.

Novelty Statement

Alternate bearing is an alarming issue in Olive varieties in Pakistani climate because there is need to cultivate such varieties which have a minimum chance for alternate bearing secondly we can control this alternate bearing by adopting different short gun approaches. The application of fertilizers with different growth hormones, proper pruning and bio stimulants can minimize the alternate bearing and increase farmer production.

Author's Contribution

Muhammad Jan: Fetched main idea of draft and write up.

Muhammad Ashraf Sumrah: Reviewed and supervised the article.

Javed Iqbal: Supervised the draft.

Muhammad Aslam: Arranged contents and table.

Rizwan Latif: Checked the article for language.

Muhammad Arif: Checked the references.

Muhammad Tahir Akbar: Finalized manuscript.

Hafiz Husnain Nawaz: Collected the related literature.

Conflict of interest

The authors have declared no conflict of interest.

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