



# Olives Production Manual



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# Table of Contents

Introduction	1
Section 1: Should I Plant Olives? Economic Considerations	3
Olives for Table Consumption and Production in Iraq	4
Table Olives Profitability	5
Olives for Oil	8
Section 2: Site Selection	11
Section 3: Variety Selection Factors for Iraq	13
Suggested Varieties	15
Section 5: Planting an Olive Orchard	30
Section 6: Irrigation	33

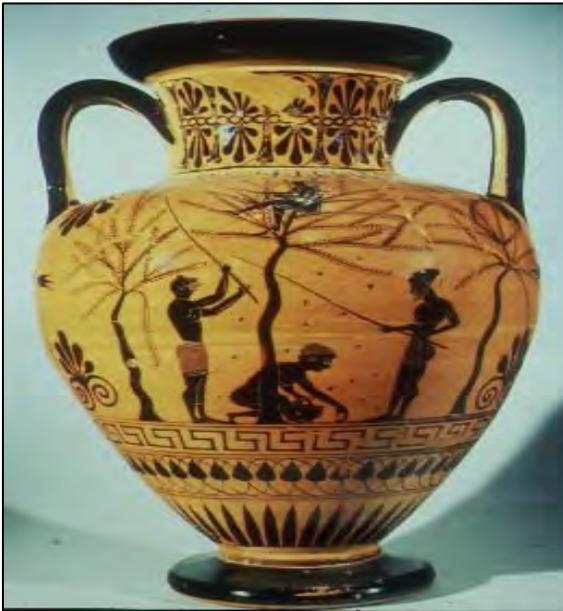
## Introduction

The olive tree, *olea europaea L.*, is valued for both its beauty and fruit. The olive was native to Asia Minor and spread from Iran, Syria and Palestine to the rest of the Mediterranean basin 6,000 years ago. It is among the oldest known cultivated trees in the world - being grown before the written language was invented. It was being grown on the Isle of Crete by 3,000 BC and may have been the source of the wealth of the Minoan kingdom. The Phoenicians spread the olive to the Mediterranean shores of Africa and Southern Europe. Olives have been found in Egyptian tombs from 2,000 years BC. The olive culture was spread to the early Greeks then the Romans. As the Romans extended their domain they brought the olive with them.

The use of olive oil is found in many religions and cultures. It has been used during special ceremonies as well as a general health measure. It has been part of the Mediterranean civilization since before recorded history. As early as 3,000 BC, Syrians cultivated the olive and traded in oil. Numerous references to the olive, its cultivation, and to the use of olive oil date back to 2,000 BC.

Although Iraq is now a minor producer of olives, the country has a rich heritage in olive production and the use of olive oil. Olives are currently being produced most of the climatic zones of Iraq.

Production in 2002 amounted to 11,000 metric tons, compared to neighboring countries Jordan with 180,900, Syria with 999,000, and Turkey with 1.8 million metric tons.



Ancient Olive Oil Container

## Section I: Should I Plant Olives? Economic Considerations

The decision to plant olives represents a long term commitment of land, grower time, and money. The concept needs to be evaluated to determine if it is the best use of a farmers land and other resources. Some of the factors to be considered are:

- **Market for the olives or the olive oil:** A farmer should be assured that there is a market channel for his product, and he must be sure that he can meet the price and quality demands of that identified market. The best returns come from processing table olives, if there is a market for the product.
- The Iraqi domestic market should be considered as the primary target at this point in the development of the olive industry in Iraq. Olive production is relatively small and does not meet domestic consumption demands and Iraqi quality currently does not meet export standards.
- **Alternative crops:** A farmer should consider alternative crops and determine which holds the greatest likelihood of profitable production under his conditions.
- **Business Plan:** After consideration of the first two points, if olives still appear to be a desirable crop, a business plan should be developed using realistic cost and revenue figures. A decision to plant olives

should only be made if a realistic business plan indicates a strong possibility of an acceptable return on the investment.

## **Olives for Table Consumption and Production in Iraq**

Olives are in high demand in Iraq. In 2011, Iraq imported more than 10,000 metric tons of olives from Turkey for a value of \$15.3 million (\$1.50 per kilogram)<sup>1</sup>. This quantity represents a 35 percent increase as opposed to 2009 when only 7,500 metric tons were imported, which nearly doubled the quantity imported in 2008 (4,900 metric tons).

Unfortunately, the COSIT – WORLD BANK Survey on Iraqi Households Expenditure (IHSS)<sup>2</sup>, which is currently used to calculate per capita consumption of vegetables & fruits, has no separate data for olives.

Turkey is the biggest exporter of table olives to Iraq at an estimated 80 to 90 percent of all olives in the country from Turkey. Other olive exporters include Palestine, Syria and Spain (canned and bottled).

There is no definitive data on current Iraqi olives production but some evidence shows, as confirmed by

<sup>1</sup>COMTRADE, 2011.

<sup>2</sup>COSIT and The World Bank Survey Iraqi Households Socioeconomic Survey March 2008

the numbers of imports, the demand for olives exceeds the supply. The USAID-*Inma*'s December 2010 report on olive and olive oil production and the Iraq Ministry of Agriculture's 2010 estimate shows a minimum of 600,000 fruiting trees concentrated in the Bashiqa area in Ninawa province with yields ranging from 10 to 30 kilograms per tree.

As a result, under the assumption that an average yield of 15 kilograms olives per tree, the total consumption (demand) of olives in Iraq would be in the range of 19,000 metric tons of which 10,000 metric tons are currently imported.

The Iraq Ministry of Agriculture suggests there is an opportunity to domestically produce the currently imported quantities of olives (10,000 metric tons), which would generate an import-substitution while creating an income opportunity for farmers.

## **Table Olives Profitability**

### **Price**

Based on USAID-*Inma* Technical Assessment conducted in December 2010<sup>3</sup> by olive oil expert Paul Vossen of Paul Vossen Ag Consulting and current University of

<sup>3</sup>Assessment of the Olive Growing and Processing Practices for Oil in Kurdistan" by Paul Vossen, December, 2010.

California Cooperative Extension - Farm Advisor, table olives are worth, at farm gates, a minimum of ID650 per kilogram (\$0.55) at the end of the season (for poor quality) and ID900 per kilogram (\$0.77) for most of the season with an average ID750 per kilogram (\$0.65) that is the used in this paper to calculate profitability.

## **Cost of Production**

The cost of producing table olives is calculated on the following assumptions: (Based on USAID-*Inma* Technical Report)<sup>4</sup>:

- Density around 200 – 250 (maximum) trees per hectare
- Limited use of fertilizers, commonly limited to manure at 400 kilograms per hectare (2 kilograms per tree)
- Limited use of defensives
- Manual harvest, meaning on average 100 kilograms per day
- Labor at ID20,000 per day (\$17)
- Losses of 10 to 15 percent in the harvest (culled olives unsuitable for table)
- Yields at 30 kilograms per tree at full maturity (after seven years). First yields at year four, average yields between years four and six around 15 kilograms.

<sup>4</sup>IBID

Based on these assumptions, the cost of producing olives should be no more than ID350 per kilogram (\$0.30 per kilogram) most of which is variable costs (70 percent) namely labor for harvesting, pruning and orchard management.

## **Margin**

Assuming prices at ID750 per kilogram (\$0.55) and production cost at ID350 per kilogram (\$0.30) farmers would have a very interesting margin of ID400 kilogram (\$0.34).

## **Financial Analysis**

### **Assumption:**

The estimated investment to produce table olives is in the range of \$1,250 per donum (details here below):

- \$3,500 for a ten horsepower pump for an orchard of 10 donums with useful life of 10 years.
- Drip irrigation system \$780 per donum, useful life 10 years.
- Saplings at \$4 units, orchards with 50 trees per donum (200 per hectare).

Average selling price ID750 per kilogram (\$0.64)

Total production cost ID350 per kilogram (\$0.30)

Net Margin ID400 per kilogram (\$0.34)

Return on Investment (measured by the Internal Rate of Return) should be both positive and interesting.

Estimate would include a 13 percent return in the first 10 years and 19 percent if calculated for the years after the seventh year in a 20-year investment.

## **Olives for Oil**

Olive oil is a low margin, very competitive business. According to the International Olive Oil Council, world production and consumption are in rough balance around 2.8 tons of olive oil per year. Production peaked several years ago at more than 3 million tons, but has dropped slightly in recent years. The World Olive Council expects a crop of 3 million tons in 2011.

China and the United States represent the two of the largest expanding markets for the product. The European market is static and in most cases over supplied. European oils are subsidized to make them cost competitive.

It is unlikely that Iraq will soon become cost competitive in the high volume export markets for medium to low quality oils. Production for domestic sale is currently the most viable market.

Another possibility is the high end, extra virgin gourmet oils for niche markets in the U.S. and other countries with large Iraqi immigrant populations. There is potential in this area, but the Iraqi producers will have

to greatly improve the quality of their product before there will be a realistic chance of success.

Production for table use, with the inferior olives going for oil sounds attractive, but it is difficult to do both well. Frequently the optimum harvest period for oil and for table use is different within a variety. In other words, one will suffer to the advantage of the other. Olives that had started through the curing process should not be used for oil, or if used, this oil must be kept completely separate from other oils to keep the off flavors from spoiling the good oil.

Based on the following assumptions;

- Density of 200 to 250 trees per hectare
- Limited use of fertilizers, commonly limited to manure
- Limited use of Integrated Pest Management (IPM)
- Manual harvest, meaning on average a total of 100 kilograms per day per laborer.
- Labor at ID20,000 per day (\$17)
- Net price at farm gates at approximately ID600 per kilogram.

The cost of producing olives is estimated at ID450 per kilo. Approximately 40 percent of this cost is harvesting labor. Based on a yield of 20 kilograms per tree, farmers should make between ID150-ID200 per kilogram of olives. A yield of less than 20 kilograms per tree will probably not be profitable.

## Conclusions

- Few growers are currently obtaining yields of 20 kilograms per tree. Yields need to be increased through better use of fertilizers, IPM, and irrigation. Farmers planning new orchards should consider planting high oil content varieties at a higher density to increase both yields per donam and the percentage of oil extracted.
- Harvest aids must be introduced to increase the productivity of harvest labor and reduce harvest cost.
- Cull olives should be graded out prior to the start of processing for table olives, and not run through the oil pressing facility after they have started in the brining process.
- Greater care must be taken to improve sanitation and cleanliness in the oil pressing facility to improve the quality of the final product.
- Oil processors must identify the market segment that they are going to serve and make sure that the quality of the oil they produce meets the requirements of those customers.
- Olive oil is a low margin, highly competitive business and Iraqi producers will have to improve all facets of production and processing if they are going to be successful.

## **Section 2: Site Selection**

### **Choose Planting Sites for Best Olive Conditions**

Olives need mild winter temperatures, long, warm, dry summers, and no frost near bloom or before harvest. Areas with frequent high winds should be avoided.

### **Avoiding Locations with Damaging Climatic Conditions**

Small branches can be damaged or killed by temperatures below  $-6^{\circ}\text{C}$  and large limbs or the entire tree can be killed by temperatures below  $-9^{\circ}\text{C}$ .

Some chilling is required for flowering and fruit set. Studies have shown that optimal flowering occurs when the daily winter temperatures range from a minimum of  $2^{\circ}\text{C}$  to  $4^{\circ}\text{C}$  and a maximum of  $16^{\circ}\text{C}$  to  $18^{\circ}\text{C}$ .

High winds, particularly in the summer can desiccate the leaves and cause great damage to the trees.

### **Soil Conditions Best Suited to Olive Production**

Olives prefer unstratified, moderately fine textured soils. These may vary from a sandy loam to a clay loam. Such soils provide aeration, are quite permeable, and have adequate water holding capacity.

Very sandy soils do not have sufficient water holding capacity, and heavier clay soils do not provide the aeration necessary for root growth. These soils are difficult to manage for maximum production. Stratified soils impede water drainage and water logged soils will damage olive roots.

The Olive tree is moderately tolerant to soil salinity provided the electro-conductivity of the soil is kept less than 4.5 deciSiemens per meter. Olives will tolerate some mild soil acidity (pH 5 to 7), but produce best on slightly basic soils with a pH of 7 to 8.5. Olives will tolerate relatively high levels of boron (up to 2 pounds per million), and chloride up to 10 to 15 milliequivalents per liter in the soil. However, Sodic soils, characterized by a disproportionately high concentration of Sodium (Na) in their cation exchange complex, should be avoided unless they can be reclaimed by leaching and addition of soil amendments.

## **Water Requirements**

As a general rule, mature olives require about 2,500 to 3,000 cubic meters per donum to provide 100 percent of the crop evapotranspiration. Developing trees from planting to maturity need near 100 percent of the crop evapotranspiration value to make maximum growth and reach maturity. Studies have shown that mature trees will maximize production with irrigation at 50 to 70 percent of the crop evapotranspiration value.

Olives for oil, will produce the best flavored oils with irrigation at 35 to 55 percent of the crop evapotranspiration values.

## **Water Quality**

Farmers should avoid irrigating with water that contains;

- High Boron; more than 2 ppm Boron in excess can be toxic to plants;
- Bicarbonate; more than 3.5 ppm Bicarbonate can raise the pH of the soil;
- Total Salt; more than 3 deciSiemens per meter of electro-conductivity of water;
- High Sodium; more than 3 milliequivalents per liter;
- High Chloride; more than 345 ppm.

## **Section 3: Variety Selection Factors for Iraq**

### **Recommended Varietal Characteristics**

Generally desirable characteristics for consideration in selecting olive varieties include;

- Low Tree Vigor; (low vigor allows closer spacing, earlier production, and easier harvest.)
- Large Fruit
- Easy Harvest
- High Yield

- High Oil Content
- Good Flavor
- Correct style (the product must meet the preference of the intended market)
- Cold Hardy (a possible factor in Kurdistan)
- Maturity Season (should match climate, processing capacity, and available labor)
- Disease Resistance
- Pollinators Required

Numerous scientific research trials have proven that the pollen of the same variety germinates and fertilizes the egg over a longer period of time compared with pollen of a different variety. Consequently, when environmental or management conditions are not optimal, the presence of pollen from another variety will normally guarantee a better fertilization and fruit set. Different varieties show different responses to stressing and non-stressing environmental conditions regarding their fruit set levels without cross-pollination. This situation creates different degrees of self-compatibility or self-incompatibility in olives. Many research studies have proven that in nearly every case most varieties improve their fruit set with the presence of pollinators.

Even when pollen is carried several hundred meters under certain conditions, if cross-pollination is to be effective, pollinators must be placed no further than 35 to 60 meters away. Many studies around the world

show that the density of pollen grains greatly decreases as distance from the source is increased. Recommended pollinizer's, when available, are listed in varietal information below.

## **Varieties Recommended by USAID-Inma Specialist for Trial in Iraq**

- Continue with Iraqi varieties using new techniques to maximize yield and quality
- Test new varieties in small planting before wide spread adaptation.

## **Suggested Varieties** **Picual**

The Picual olive comes from Spain. Plantings in Chile, Australia and New Zealand are proving the value of this highly productive early harvest variety. Picual is easy to harvest and contains a high content of easily separated pungent oil, which stores well. In Spain, Picual is a popular table olive known to be high in beneficial substances such as oleic acid and vitamin E. Picual is cold hardy and self-fertile, but produces higher yields when paired with a pollinizer such as Manzanillo.



## **Coratina**

The Coratina olive comes from Italy. It is an excellent for oil and table fruit. It has good adaptability to different soils and climates. It is rated as cold hardy. Pendolino is the recommended pollinator. Coratina is medium size and moderately pendulant shape. The expansive crown tends to be a globular shape and has long flexible branches. The leaf is deep green in color, elliptical in shape and ends in a slightly mucronate shape. There is usually high yield at the mill (21 to 23 percent) as well as high quantity of polyphenols (590 mg/kg). Its oil, when freshly extracted, is fruity and pungent with bitter aftertaste. This is a late harvest olive.



## **Arbequina**

The Arbequina olive originates in Spain. The tree has an upright habit and is an ideal high density planting variety. It is a productive variety that enters into production early.



This cold hardy variety is considered rustic with good resistance to frosts and with high adaptability to different climates and soils (including poor ones). The olive is susceptible to black scale (*Saissetia oleae*) and peacock spot (*Cycloconium oleaginum*). The yield in oil is good (averaging 20 to 22 percent), of excellent quality with good organoleptic characteristics but is often associated with low polyphenols content. The Arbequina oil is sweet, delicate and fragrant with intense fruitiness but low levels of bitterness and spiciness. Arbequina produces a mild-flavored oil. This is an early season harvest and is self fertile. It adapts well to dense planting because of its small size, but it is poorly adapted to mechanical harvest by shaker because of the small size of the fruit, the pendant shape of the tree and the strong attachment of the fruit.

## Arbosana

The Arbosana tree produces large amounts of small olives with high concentrations of premium olive oil. Arbosana olive trees start producing olives after two years, and reach full fruiting in five years. The Arbosana flavor is a complex mixture of fruitiness with a good balance of pungency and bitterness.



It is often blended into oils from other olives to improve their taste and aroma. These trees can be planted very densely in orchards. The late-bearing Arbosana variety is fairly cold hardy, though not as hardy as Arbequina. Like Arbequina, Arbosana is self-fertile, but produces higher yields when paired with a pollinizer such as Arbequina or Koroneiki .

## Hojiblanca

The Hojiblanca olive is from Spain. The Hojiblanca is a plant of good vigor with long fruit bearing branches. It has an average size crown and a dense regular foliage cover. The name means "white leaf" and refers to the color of the back side of the leaves. The fruit is medium in size (averaging 4.3 grams) and is used for brined olives as well as oil. The Hojiblanca has a high fruit to flesh ratio with a yield of oil of 17 to 19 percent. It generally ripens late (toward the end of November), but the fruit resists the cold quite well. It usually blossoms in the second week of May. Late in maturity, the fruit has a strong attachment. The leaf is elongated, partially fluted, but rather wide. The Hojiblanca is a cold hardy variety.



## Leccino

The Leccino olive is from Italy and is a cold hardy variety, which accounts for about 16 percent of the oil grown in Tuscany, which makes it one of that region's main varieties. The Leccino is a vigorous tree with a dense canopy. It adapts easily to various olive growing environments. The fruit shape is oval and medium sized. It ripens simultaneously from the tip end first and ripening is early in the season. This allows the fruit to be picked early without loss of yield. The Leccino is well known for the quality and character of the oil it produces. The oil content is medium and lower than the Frantoio. High moisture content at processing makes extraction less efficient. The oil is superbly balanced and palatable fresh of the press with out the harsh bitterness associated with some oils. In Tuscany, it is often blended with Frantoio olive. It is pollinized by Maurino or Frantoio olives.



## Kalamata

The Kalamata olive is from Greece. The olive is a fruit of high weight of an elongated asymmetric shape that is quite distinctive.



While it makes excellent oil it is chiefly grown for Greek style black olives. It is freestone with a good pit to pulp ratio. Productivity is high but alternate. Flowering is intermediate. Beginning of bearing is intermediate. Overall, the variety is of medium hardiness. It has medium oil content (12 to 18 percent) of good quality. The fruit ripens mid to late season. The variety is resistant to cold but sensitive to excessively hot climates. It is somewhat susceptible to olive leaf spot and verticillium wilt, but resistant to olive knot (*Pseudomonas savastanoi*).

## Mission

The Mission olive is a vigorous variety with an erect growth habit. It is the oldest California variety. Originally from Spain, it spread up the state from Baja California with the establishment of the missions. Its popularity as a table variety has decreased in recent years, but it is a perennial favorite for oil production. It tends to alternate bearing, but this can be minimized somewhat with cultural practices. It is considered very tolerant of cold and salinity, and moderately tolerant of drought. Mission is also a good table cultivar. It is freestone and can be harvested green or ripe for a variety of different

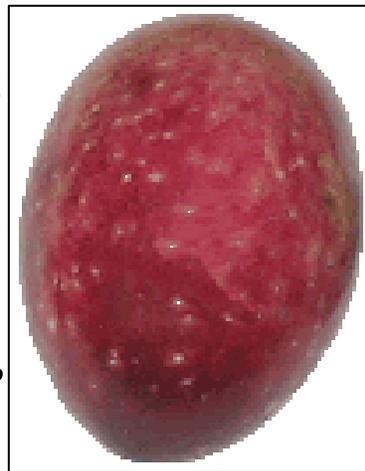
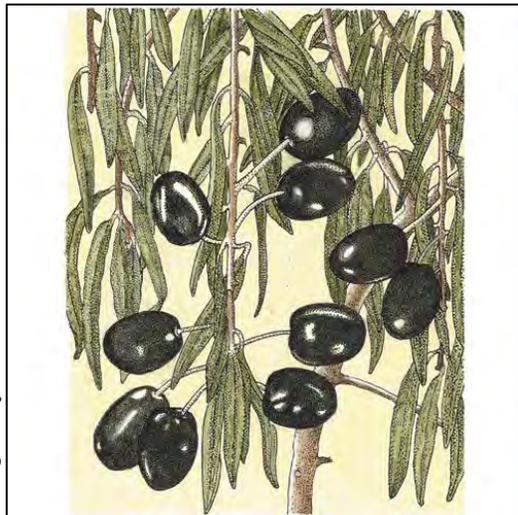


table olive styles. This cultivar has a high yield of good quality oil. Aggressively bitter when it is harvested too green, the Mission olive is best harvested for oil when moderately mature. Mission has a medium removal force. Its upright growth habit makes it well suited to mechanical harvesting. It ripens late and is frequently harvested early in the year for late harvest style oils.

## Manzanillo

The Manzanillo olive is a Spanish olive that is low to moderate in vigor, with a spreading growth habit and medium density. It is the most widely planted table olive variety in the world and accounts for the majority of the table olive production in California. It tends to alternate bearing, but this can be ameliorated



with appropriate cultural practices. In Spain it is treated as self fertile, but in other countries yields are improved by the presence of pollinizers. Mission and Ascolano olives are not suitable pollinizers for the Manzanillo variety. It is moderately tolerant to both cold and drought. The Manzanillo is very susceptible to ver-ticillium wilt and the olive knot. The fruit of the Manzanillo is round and freestone, with a high ratio of flesh to pit. It is harvested green for curing as “California black ripe” style olives, but can also be picked when

changing color. Manzanillo can also make a good oil with distinctive varietal character. The oil is notoriously difficult to extract, however, particularly when the water content of the fruit is high. The oil obtained from early harvest Manzanillo is usually regarded as superior to that from riper fruit, which is fortunate because ripe Manzanillo is also harder to work with. It results in a wet sticky paste that forms emulsions easily and hinders the extraction of the oil. The removal force of Manzanillo is high. Traditionally it is harvested by hand for table olives, but recently developed mechanical harvesters are showing some promise.

## **Gordal (Sevillano)**

The Gordal olive is a product of Spain. It is a very large fruit that turns bluish-black when ripe. It is one of the largest commercial varieties. Its name is derived from



gorda or “fat” in Spanish. The Gordal seed is stone large and clinging. The fruit also ripens early. This is the “queen” olive for the people of Sevilla, and the reason why it is also called “Sevillana”. The Gordal is a firm, fresh, plump green olive with a rough and meaty texture. It is a table olive, which is often pitted and stuffed with peppers. Maturity for the Gordal is early.

It is pollinized by the Manzanilla. This tree has good resistance to cold, humidity and olive fly.

## **Nocelara Del Belice**

The Nocelara Del Belice olive is characterized by the shape of its branches and by the expansive crown of modest growth. The leaves are lanceolate, large and intense green in color.



The fruit has a notable weight (5 to 7 grams) with a large base and rounded top. The flesh, which is very consistent in texture and prized for brining, represents 85 to 88 percent of the fruit. The maturation is late, but if the fruit is for canning and the harvest is over before winter.

The plant is self-incompatible, of medium and consistent productiveness. Pollinators include the Giarruffa and the Biancolilla. It is partially resistant to cold and diseases, such as peacock spot (*Cyloconium oleaginum*) and olive knot (*Pseudomonas savastanoi*). The oil content is approximately 20 percent and is light and perfumed. Harvest for the Nocelara Del Belice is from September to November in Italy. It prefers a deep moist soil, and owes its wide spread planting to the bounty of its product.

## Picholine

The Picholine olive is a product of France. The Picholine is considered hardy with a tolerance for cold, and adapted to a variety of conditions. The tree is moderate in vigor, and has a spreading growth habit and medium density. It has a reputation for being demanding as far as its care is concerned. With adequate irrigation, Picholine is a constant, high producer. It is considered the most important French variety. Although it is partially self-fertile, the Manzanillo and Leccino are considered good pollinizers. The Picholine will start bearing fruit early while ripening late in the season. When harvested too green it is very bitter, but if allowed to ripen more, it yields a fruity oil with a pleasant balance of bitterness and pungency. Picholine fruit is medium to large and freestone. It is primarily used for making green table olives, but it is also an important oil variety. The oil yield is medium, but it is highly regarded for its quality. For pickling, Picholine is harvested when yellowish green. For oil, the fruit should be reddish black.



## Suggested Varieties

Olive planting patterns are a much discussed topic. Optimal olive orchard designs involve planting trees to utilize space efficiently and maximize sun exposure. In many olive-growing regions outside of Iraq, machine harvest and super-high-density orchards are becoming common. Trees must be then be spaced and pruned specifically for the production system to be used.

The olive tree bears fruit on one-year-old wood found on its outer periphery in the presence of adequate sunlight. Olive shoots do not flower and do not produce fruit in full shade. If the trees are planted too closely, shading eventually reduces orchard production. A mature orchard is considered at optimum bearing potential when trees are spaced at the greatest density that still allows them to intercept enough sunlight for annual shoot growth throughout the tree's periphery.

New olive orchards must produce economic crops as soon as possible. How soon an orchard reaches economic bearing depends on tree density. Before trees reach full size and utilize all allotted space and sunlight, per-acre production is directly related to the number of producing trees. Olive orchards are often planted with filler trees at high densities to use the sunlight most efficiently and reach maximum production before the trees reach full size. Such high-density plantings assume that filler trees are removed as they grow

crowded and their shading interferes with production.

The ultimate size of an olive tree is the primary determinant of final tree spacing in a mature orchard. Cultivar and soil largely determine the tree's ultimate size. For example, among varieties, the Sevillano, Mission, and Ascolano varieties are vigorous and grow to a large size. Manzanillo is a moderately sized tree and requires less space, and Arbequina is a small tree ideal for closer spacing.

All cultivars develop their maximum size on fertile, well-drained soils. Trees on marginal soils do not grow as large. Sites with deep soil, high moisture holding capacity, and high fertility should have trees spaced farther apart than sites with shallower soils, poor water holding capacity, and low fertility or less intensive management.

Hard pruning to keep olive trees of most varieties small, normally results in vigorous shoot growth and poor production, so it is important to keep the size of the adult tree in mind when designing the layout.

There is no exact recipe for tree spacing. It depends on the variety, terrain, climate, proposed harvest method, tree training systems, fertility, irrigation management and soil conditions. Spacing ranges from as close as 0.9m by 3.7m to as far apart as 8.5m by 8.5m and every combination in between. For the purposes of

this manual we suggest the following definitions.

## **High Density**

Trees planted 4 X 1.2 meters (Arbequina and Arbosana only) 2083 trees per hectare

Trees should be 2 meters wide and 3 meters tall at maturity.

## **Advantages / Disadvantages**

The high-density system has worked with three varieties, two of which USAID-*Inma* has recommended for trial in Iraq: Arbequina, Arbosana, and Koroneiki. Any other variety closely spaced may have excellent results for the first few years, but eventually the trees grow too big for their allotted amount of space, grow too tall, and shade the lower portion of the trees. The high-density system never allows the trees to exceed a size of about 2.7 to 3.0m by 1.8 to 2.1m through annual renewal pruning. The trees are planted 1.5m by 4.0m apart in high vigor sites to 1.2 by 3.6m apart in low vigor sites. Only highly self-fruitful, precocious varieties will fruit under the conditions of close spacing and heavy pruning. It also helps if the orchard manager can control soil water status to moderate tree vigor. It is anticipated that this system will be more difficult to manage in places with deep soils and high rainfall.

Due to the recent advent of high-density planting, many questions still exist as to how this spacing will

hold-up over time, and what costs will be involved with thinning, if any.

USAID-*Inma* suggests that this system is not compatible with the current situation in Iraq of small individual plantings of olives. This planting system is more compatible with larger, industrial sized plantings because of the need for expensive specialized harvest equipment.

### **Medium Density (All Varieties)**

7 X 3.5 meters (408 trees per hectare)

6 X 3 meters (555 trees per hectare)

5 X 2.5 meters (800 trees per hectare)

Trees should be 4 meters tall

## **Advantages / Disadvantages**

These orchards are planted at a medium-density of about 408 to 800 per hectare. Generally, the more trees planted per hectare, the faster the planting comes into bearing. Any variety can work in a medium-density setting.

The first decision to be made before selecting a design is whether or not filler trees are to be used to increase tree density and early production. . An orchard planted with filler trees begins production sooner and reaches higher production levels than an orchard with standard spacing during the same period. The greater number of trees per hectare, however, translates into

higher development, managerial, and production costs. Removing the filler trees once the orchard gets crowded is expensive, as is modifying the irrigation after the trees are removed.

USAID-*Inma* recommends that Iraqi growers, who are considering new olive orchard development, consider using one of the medium density planting schemes listed above. This will encourage earlier production, and higher yields at maturity through more efficient use of water and sunlight.

**Low Density or Traditional Spacing (All Varieties)**  
7 X 7 meters (204 trees per hectare)

## **Advantages / Disadvantages**

Traditionally, olive trees were planted at a spacing of 7m X 7m. This is no longer popular anywhere in the world except for dry, non-irrigated regions. This spacing does not maximize efficient use of sunlight, and should only be considered in non- or partially irrigated areas with marginally sufficient rainfall.

USAID-*Inma* recommends that this only be considered for Iraq in areas where water supply is very limited and where even with drip irrigation there is not sufficient water to support a higher density planting.

## Section 5: Planting an Olive Orchard

### Tree Source

A Kurdistan Ministry of Agriculture nursery operates near the road between Bashiqa and Mosul. It is in the Khabat District. It was started as a 1999 United Nations' Food and Agriculture Organization



*Ministry of Agriculture greenhouse*

Project. They have the following varieties, including four recommended by USAID-*Inma*.

- Sourani
- Khthaery
- Khalkhaly
- Qesy
- Bashiqa
- Fathlea
- Armeta
- Picual
- Arbequina
- Hojiblanca
- Mission
- Manzanillo
- Ascolana

## **Field Layout**

The most common designs for permanently set trees are:

### **Square**

Square is the most common design. Trees are equally spaced within and between rows. This type of orchard is easy to layout and orchard operations can be carried out in both directions. Irrigation drip lines, however, may impede this. It is not generally used when filler trees are planned, as distances between trees and within rows eventually become too small for efficient orchard care.

### **Offset square**

The offset square system is similar to the square design except that trees in adjacent rows are offset. This system is less popular than the square system. It is more difficult to layout and, unless farmed on the diagonal, the rows are closer.

### **Hexagonal/Equilateral Triangle**

The hexagonal/equilateral triangle system is similar to the offset square except that distances between trees in any direction are equal. This is only adaptable to plans without filler trees. It allows 17.5 percent more trees per hectare than the square or offset square systems at any given spacing and therefore is more efficient in use of sunlight and land.

## Site Preparation

Criteria for site selection are listed earlier in this manual. Preparation for planting should begin in the fall prior to planting. The field should be chiseled to a depth of at least 30 cm to 50 cm to break up any compaction. Deeper tillage could be required if severe compaction or stratification is present. Many growers, in other areas, then plant a winter cover crop, which will be disked under prior to digging the holes and planting the trees.

## Planting

The orchard is laid-out, holes are dug, and the trees planted in the spring of the year. Trees that die are replaced in the second year. Most studies assume a two percent loss. Important steps in the planting process include;

- Dig a hole twice the size of the tree container to allow room for root spreading.
- Cut the circling roots within the container with minimal disturbance of the root ball.
- Do not add soil amendments such as manure to the planting hole.

## Year One, Care after Planting

- Soak the newly planted tree and then irrigate as needed.
- Stake if the planting is in a windy area.
- Keep weeds 0.75 to 1.0 meter away from young trees.

- Fertilize lightly
- Minimal pruning is necessary during the first years after planting.

**Weed control and adequate moisture are the key actions necessary during the early years of the orchard.**

## **Section 6: Irrigation**

Olives are considered drought tolerant. However, they do not produce well without proper irrigation. Unlike deciduous trees, which are dormant in winter, olives retain their canopy and use water year-round.

### **Water Requirements for Olive Trees**

How much water will my olive trees need as they grow? There are so many factors which can effect the water requirements of any tree. **Soil type** – this is an obvious variable – a tree planted in sand will need more regular watering than a tree in clay because of the fast draining nature of sand. **Climate** – if trees are planted in an area which receives 350 days of sunshine per year they will need more water than those planted in a cloudier climate which may only receive 200 sunny days per year. Climate is directly related to the evaporative demand or Evapotranspiration. **Stage of growth** – olives have certain development periods that are especially sensitive to

dry soil conditions. It is important do not allow any water stress during bloom (see table):

## **Effect of Water Stress at Bloom**

Water stress timing	% Leaf drop	# Flowers/ Inflorescence	% of Perfect flowers	# Fruits/ 100 Inflorescences
No stress	2.8	15.7	27.4	3.3
Stressed bloom	4.8	8.3	9.3	0.6

Generally, reference crop evapotranspiration or potential evapotranspiration (ET<sub>o</sub>) is determined for use as a base level. ET<sub>o</sub> represents the water use from a uniform green-cover surface, actively growing and well irrigated. Crop water requirement is related to ET<sub>o</sub> by a crop coefficient (K<sub>c</sub>) which is the ratio of crop water use (ET<sub>c</sub>) to the reference value ET<sub>o</sub>. The most significant plant factor affecting Etc is the total leaf area intercepting solar radiation. Thus, tree canopy size, planting density, and leaf-development stage all influence crop water use.

For calculating the potential evapotranspiration (ET<sub>o</sub>), the Penman-Monteith equation is recommended. The olive crop coefficient, K<sub>c</sub>, adjusted to Iraqi growing conditions was established in 0.75. Thus the olive evapotranspiration (Etc) was determined according

to:

$$E_{tc} = E_{To} * K_c * K_r$$

$K_r$  represents the reduction coefficient which takes into account the percentage of canopy cover ( $C$ )

$$K_r = 2 * C/100$$

To determine olives' water requirements ( $IR$ ) the olive evapotranspiration was reduced by the effective precipitation ( $R$ ), as follows:

$$IR = E_{Tc} - R$$

Although in the North of Iraq water salinity levels are lower than the threshold values, it is necessary to determine the "leaching requirement", which is an extra amount of water that is necessary to apply to keep the salts out of the root zone. The leaching requirement calculations depend on the type of irrigation system.

Based upon these calculations, water requirements for a mature olive tree in the northern region where olive trees are planted in Iraq is 1,155 mm (11,550 m<sup>3</sup>/ha/year or 2,880 m<sup>3</sup>/donum/year). However, water requirements of mature oil olive trees are reduced by 45 to 55 percent, i.e. 578 mm (5,780 m<sup>3</sup>/ha/year or 1,445 m<sup>3</sup>/donum/year).

## Irrigation Systems

Irrigation system selection is based on initial and maintenance costs, topographic characteristics, and water availability. Drip and mini-sprinklers are expensive but very efficient and well adapted to any topographic condition. Drip technology also allows significant savings in water, labor and energy required for pumping the water. Probably the most important feature of drip systems is the capacity to improve fertilizer use efficiency, which might be the principal reason for yields improvement. Sprinklers are less efficient; they apply more water per unit time and are suitable when run-off does not occur. Surface irrigation demands more water, is highly inefficient, however this can be improved by leveling the land and introducing gated pipes.

Drip irrigation has been selected to be implemented in two demonstration areas in Ba'ashiqā (Ninewah province). A double line of emitters are going to be placed putting the emitters right next to the tree trunk if planting when weather can get hot. Next year, the emitters must be moved away from the trunk at least 24 inches. Young trees should never be allowed to go dry and should never suffer water stress. This means that young trees will need frequent irrigation during summer, i.e. daily or at least every other day.

Volumes of water necessary to apply in Iraq, based on the age of 7 x 7m olive trees are presented in the following table:

Year	Volume	
	Year	Summer
New planted tree	1.1 l/tree/week	1.5 l/tree/wee
1	5.0 l/tree/week	1.0 l/tree/day
2	2.3 l/tree/day	3.1 l/tree/day
3	5.7 l/tree/day	7.5 l/tree/day
4	12.0 l/tree/day	15.0 l/tree/day
5	22.0 l/tree/day	29.0 l/tree/day
6	37.0 l/tree/day	49.0 l/tree/day
7	60.0 l/tree/day	78.0 l/tree/day
8	91.0 l/tree/day	119.0 l/tree/day
9	133.0 l/tree/day	174 l/tree/day
10	161.0 l/tree/day	211 l/tree/day

Based on the volume of water applied per tree and the discharge and number of emitters, the respective irrigation times were easily determined.

## Soil Moisture Monitoring

In order to adjust the irrigation times, soil moisture monitoring devices are considered. Mainly tensiometers and resistance blocks placed at different depths in a single location.

Tensiometers register the soil moisture tension as soil water is depleted. Soil moisture tension refers to how strongly water is held on soil particles, the higher the tension the more difficult it is for plant roots to extract water from the soil. Charts provided with the instruments relate the gauge reading to percent soil moisture depletion based on soil texture. Tensiometers are better suited to sandy and loamy soils than clay soils because they are not mechanically capable of measuring the high tensions at which water is still available in fine-textured soils.

Resistance blocks, also called gypsum blocks or resistance blocks, evaluate soil moisture tension by measuring the electrical resistance between two electrodes. The blocks take up and release moisture as the soil wets and dries. The higher the water contents of the blocks, the lower the electrical resistance.

The key to proper irrigation management using soil moisture sensors is to monitor the sensors regularly, track the soil moisture level, and irrigate when the

tension readings are in the desired range for the corresponding type of soil.

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